

ASSESSMENT OF COMMUNITY ATTITUDES TOWARDS

SMART DRUMLINES AS A SHARK MITIGATION TOOL



AUTHOR DETAILS

Lead authors

Associate Professor Peter Simmons: Charles Sturt University

Peter is a Charles Sturt University Research Fellow and a member of the Institute for Land, Water and Society at Charles Sturt University, Australia. Peter's professional career and research span strategic communication in health, sport, and governmental contexts. His recent research focuses on social media, government communication, and human/wildlife relations. psimmons@csu.edu.au

Dr Michael Mehmet: Charles Sturt University

Michael is a Lecturer in Marketing, specialising in advanced qualitative research. He sits on the Social Media Reference Committee (SMRG) at Charles Sturt University and is a member of the Collaboration Laboratory (Co-Lab) at the SMART Infrastructure Facility. His PhD (UOW 2014) explored how meanings are composed in social media integrated marketing campaigns and pioneered a social semiotic multimodal and campaign approach he named *Fabric*. His current research interests involve digital, social marketing, and complex sentiment analysis. mmehmet@csu.edu.au

Contributing author

Carol Martin: NSW Department of Primary Industries

Carol is a Fisheries Scientist currently working on social research relating to the NSW Shark Management Strategy (SMS), focusing on community awareness, attitudes and support for various shark research and mitigation tools trialled in the SMS. She recently completed a PhD in cultural ecosystem services (i.e. non-material benefits obtained from natural ecosystems contributing to human well-being) derived from estuaries in NSW. Her research interests lie in the social aspect of marine and terrestrial environments, in particular, how different people value, use, and relate to natural ecosystems. carol.martin@dpi.nsw.gov.au

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1 EXECUTIVE SUMMARY

BACKGROUND TO STUDY

The ocean, the beach and sharks are important to Australians. Since 2015 the NSW Shark Management Strategy has trialled and tested a range of technologies intended to 'increase protection for bathers from shark interactions while minimising harm to sharks or other animals'.

This research was a collaboration conducted and supported by the Department of Primary Industries (DPI) NSW Shark Management Strategy (SMS), Charles Sturt University, and the Institute for Land, Water and Society.

Community attitudes play an important role in the acceptability and success of policy approaches. This study listened to beach and ocean user thinking about strategies for reducing the risk of human-shark interactions, and harm to sharks and other marine life, in three NSW regions. Each region had recently experienced trials of SMART drumlines between February and May 2019 – Bega Valley, Newcastle, and Sydney Northern Beaches.

The research explored awareness, attitudes and perceptions of advantages and disadvantages of:

- in-water shark management (SMART drumlines and mesh nets)
- aerial shark surveillance (helicopters and drones), and
- technology and monitoring (VR4G listening stations, SharkSmart App, and personal deterrents).

Before the work began, the DPI undertook community engagement and communication activities in trial areas to raise awareness and inform the community about upcoming SMART Drumlines trials. This included Council and key stakeholder briefings, media releases, beach signage, and social media communications, as well as community drop-in stands that allowed members of the public to informally discuss the SMART drumlines trials and voice any concerns.

MAIN FINDINGS

- Few clear-cut winners for shark management options
 - SMART drumlines valued somewhat
 - Mesh nets unpopular
 - Drones got the big tick
 - Helicopters too expensive
 - VR4G limited usefulness
 - SharkSmart App OK for some
 - Personal deterrents best for unpatrolled coastline

All shark management options were perceived to have strengths and weaknesses, advantages and disadvantages. There were few clear-cut, unqualified cases made for one type of mitigation rather than another. The main findings across the trial sites are presented here (the main report gives a breakdown and compares attitudes to the strategies at each site).

- **What are attitudes to, awareness of, and perceived advantages and disadvantages concerning in-water mitigation strategies? (SMART drumlines and mesh nets)**

SMART drumlines were somewhat valued at all locations for their tagging function and potential to contribute to understanding of sharks through research. As a shark management strategy, they were also appreciated for being more humane than shark nets. They were not generally valued as a strategy for reducing the risk of harm from sharks.

There were two dominant disadvantages mentioned across the trial sites concerning SMART drumlines. The trial results were considered evidence of their ineffectiveness at catching target species, and they are perceived to be cost and labour intensive to implement. There was a consensus in some groups that there must be better ways to tag sharks that reduce the risk of harm to sharks. The process of hooking and leaving a shark on a hook before tagging was often considered cruel. Perceived harm to sharks was largely associated with contractor skill and the time it takes to reach the shark and remove the hook (participants often questioned whether the 30-minute maximum target was achievable).

Some people were also concerned that repeatedly leaving the bait in an area close to people in the water invites sharks to the area and creates danger unnecessarily. Surfers who paddled beyond the breakers highlighted this. Others said they felt sharks would be likely to swim right past a hooked mullet and continue to the beach. In short, SMART drumlines were perceived to be research tools, not harm mitigation tools.

According to most participants, the single advantage of shark nets was that they make tourists, infrequent beach goers and others who were ill or under-informed about shark management, feel safer. However, groups repeatedly said that this feeling of safety was based on the incorrect belief that the nets span the whole beach. This is not the case, sharks can swim over, under and around the nets.

Mesh nets were unpopular with all groups and they emphasised:

- cruelty and indiscriminate killing of target sharks, non-target sharks and other marine life
- harm to the environment
- high cost of maintenance
- ineffectiveness with target sharks.

There was a very strong and widespread belief that shark nets were 'old technology'.

- **What are attitudes to, awareness of, and perceived advantages and disadvantages concerning aerial surveillance? (Drones and helicopters)**

Drones were the most popular strategy across the discussion groups. Drones were considered to have several advantages, including cost, non-invasiveness, and versatility to provide general surveillance and ocean rescue functions. Some disadvantages of drones that were repeatedly raised included risks from human error and their limitations in suboptimal water and weather conditions.

Helicopters were considered advantageous for their speed, non-invasiveness and ability to cover wide areas of coast, including unpatrolled beaches. Helicopters were also considered to have limited use in adverse water and weather conditions, but the main, repeated, disadvantage was their high cost and the infrequency of surveillance they provide at any one location.

- **What are attitudes to, awareness of, and perceived advantages and disadvantages concerning technology and monitoring? (VR4G listening station, SharkSmart App and personal deterrents)**

Some people valued VR4G listening stations for contributing to research and understanding of shark movements. Although VR4G was considered an effective detection technology, it is considered ineffective for reducing harm from sharks because only a tiny proportion of potentially dangerous sharks are tagged.

The SharkSmart App was considered useful as a warning of potential shark activity, most useful for those with responsibility for beaches or groups of people (eg tourist operators). The SharkSmart App was criticised for providing too many irrelevant alerts that could become an irritation, and because it was not useful or accessible to most people at risk, who are in the water.

Personal deterrents were considered advantageous as the only protection available to people using unpatrolled coastline, and for those seeking to take greater personal responsibility. Personal deterrents were considered expensive and cumbersome and not many people trusted them. They were considered to potentially lead water users to ignore danger signs and make poor decisions.

METHOD

The researchers ran 90-minute focus group discussions with beach and ocean users at each of five trial sites – Tathra, Pambula, Newcastle, and in Sydney at Avalon and Freshwater. A total of 47 beach and ocean users participated, including surfers, ocean swimmers, lifesavers, kayakers, anglers, tourism/small business operators, divers and conservation/environment organisation members. A structured line of questioning was used to explore people's thinking and reasons for the attitudes they hold concerning different approaches to managing sharks.

CONCLUSIONS AND RECOMMENDATIONS

The study identified some important attitudes and thinking among beach and ocean users interviewed.

SMART drumlines were preferred to mesh nets, but they were not considered the long-term solution

- SMART drumlines are believed to be an advance in shark management from shark nets because SMART drumlines are perceived to do less harm to sharks and other marine life;
- SMART drumlines are not considered to be the long-term future of shark harm mitigation as they did not meet community expectations and hopes for effective, efficient, non-invasive approaches to reducing risk of harm from sharks, because:
 - The small catch of target sharks in all test sites casts doubt on the feasibility of SMART drumlines as mitigation strategy;
 - The concept of removing one shark at a time on a baited hook is doubted as risk mitigation strategy, because many more sharks remain in the sea;
 - Sharks have a negative experience through the process of catch, tag and release (most people do not want sharks to suffer);
- Mesh nets fail to meet community expectations in multiple ways;
 - Mesh nets cause suffering and death to a wide range of marine life; and
 - Mesh nets were believed to be inefficient in terms of operating cost and ineffective in terms of protection.

People believe in technology-assisted mitigation of harm from sharks

There was a widespread belief that technologies will be developed or enhanced to effectively detect and deter sharks and mitigate the risk of harm to humans. There was much support for authorities' attempts (especially the NSW DPI) to research, test and try new approaches to mitigating harm from sharks. This was especially the case for attempts to move beyond nets, often considered obsolete or 'yesterday's technology'.

- Drones were perceived to be the non-invasive future of not just shark management but beach and ocean safety generally, for several reasons:
 - Low-cost of drone units and operation, especially when compared with helicopters;

- Versatility of drones as a multipurpose surveillance and rescue tool;
- Improvements in Artificial Intelligence (AI) for shark identification and other technologies; and
- Drones' speed in reaching potential victims of encounters;
- People involved in beach tourism said they especially valued the SharkSmart App. They said they believed it provided some control over locations and times to avoid using the water. Generally, they acknowledged the low number of sharks tagged severely limits the effectiveness in preventing human interactions with sharks.

An ongoing challenge: Communicating effectively about shark harm mitigation policy and strategy

The project encountered evidence that the DPI's community engagement efforts before the trials had been effective in explaining policy and strategies to those who attended. The challenges to communicate shark management policy will continue.

There was a need to distinguish what works for research and what was mitigation – eg VR4G listening stations were mainly seen as a research tool with very little use in shark management while so few sharks were tagged.

RECOMMENDATIONS

The recommendations for shark management arising from the project are:

1. Explore the feasibility (including social and economic costs and benefits) of removing nets and favouring community-preferred non-invasive shark management;
2. Address the perception that SMART drumlines attract sharks, or people may reject placing SMART drumlines anywhere near people;
3. Address the perception that SMART drumlines are effective only for research, and do not contribute to mitigating harm from potentially dangerous sharks;
4. Clarify the roles of the different elements of the strategy ie distinguish those intended for research from those intended for direct mitigation of interactions with potentially dangerous sharks;
5. Explore the feasibility of the SharkSmart App and continually improve the functionality to allow people to specify types/range of alerts received;
6. Continue to be transparent and provide evidence of the efficacy of interventions (eg SMART drumline catch and shark outcomes after release);
7. Address uncertainty about outcomes for sharks caught by SMART drumlines; rebut or justify claims of suffering before, during and after tagging;
8. Continue investing in R&D for technologies that mitigate risk to humans, sharks and other marine life; and
9. Further, develop personal deterrent approaches that focus on functionality and affordability that meets surfers' needs.

2 BACKGROUND

The beach has a significant cultural place in Australia (Walton and Shaw 2017) and sharks have a significant place in our psyche (Sturma, 1986). Australia has a long association with sharks that are a stereotypical part of our international reputation; an association that began during the early exploration of the continent and early European settlement (Sturma, 1986). While shark attacks were rare during this period, they were still seen as a formidable menace due to reporting in the Sydney Gazette newspaper and stories of shark attacks became local folklore (Sturma, 1986). From 1919 onwards, surfing became a popular ocean activity in Australia and, together with the relaxation of previous bathing taboos, resulted in more people entering the ocean to surf and swim (Francis, 2011). At that time, sharks were generally not considered a problem until a series of human-shark incidents occurred including fatalities, which eventually led to the installation of shark nets off metropolitan beaches in 1937 (Francis, 2011) that has since expanded to 51 beaches from Stockton to South Wollongong.

More recently, there was a spate of human-shark incidents in 2014-2015 on the NSW far north coast including two fatalities. This resulted in the NSW Department of Primary Industries (DPI) implementing the scientifically-driven Shark Management Strategy (SMS) in 2015. It was to complement the existing NSW Shark Meshing Bather Protection Program (<https://www.sharksmart.nsw.gov.au/shark-nets>). The SMS's primary focus is to trial and test technologies that enhance bather protection while minimising harm to sharks and other marine life.

Historically, mesh nets have been used to protect bathers, as well as permanent swimming enclosures, fixed-location lifeguard towers, and aerial surveillance (helicopter and plane) along the coast to mitigate the risk of human-shark interactions. However, lethal mitigation approaches such as shark nets and culling – which the broader community once widely accepted - are becoming increasingly controversial. This can be attributed to socially unacceptable impacts on both target sharks (i.e. White, Bull and Tiger) and non-target marine species as well as public perceptions that shark bites are accidental rather than intentional (NSW DPI, 2017 & 2018; Neff and Wynter, 2018).

A range of shark research and mitigation approaches incorporating the use of new technology has been trialled at several locations in NSW (<https://www.sharksmart.nsw.gov.au/>). This includes SMART (Shark-Management-Alert-in-Real-Time) drumlines (SD), drone and helicopter aerial surveillance, and a network of 21 satellite-linked VR4G listening stations to detect and track tagged sharks in real-time, issuing alerts to the

public and beach authorities via Twitter and a SharkSmart App. Data from the network of listening stations also provide important insights into the distribution and movements of tagged sharks to improve knowledge and understanding of sharks. Additionally, the SMS has funded research to test the efficacy of several commercially available personal shark deterrents developed to reduce individuals' risk of interactions with sharks (Huveneers et al., 2018).

Unlike traditional lethal drumlines, SD are designed to be non-lethal: sharks are tagged and released alive (<https://www.sharksmart.nsw.gov.au/technology-trials-and-research/smart-drumlines>). When a shark takes the SD bait, an alert is sent to operators through a satellite-linked communication unit. Those operators respond immediately to tag and release the animal within 30 minutes. As a mitigation tool, SD are used to intercept sharks near beaches and relocate them one kilometre offshore, reducing the chances of human-shark interactions occurring. Tagging/tracking data indicates released sharks tend to move further offshore in the short to medium term, thereby further mitigating the risk of interactions with sharks. As a research tool, SD have been used extensively in the shark-tagging program due to their effectiveness in catching target sharks with minimal bycatch. To date, SD have been trialled as a research and shark risk mitigation tool at several locations along the NSW coast. There have been two SD trials in tandem with two shark net trials to test the efficacy of both methods (Dec 2016 to May 2017 and Nov 2017 to May 2018). Further SD trials have occurred at Coffs Harbour, Forster, Kiama and Ulladulla (Aug 2017 to Feb 2018), and most recently at Newcastle, Sydney's Northern Beaches, and the Far South Coast Bega Valley (Feb to May 2019).

Social research is an important element of the SMS to determine community attitudes towards different shark mitigation approaches to inform management decisions and recommendations. This enables management strategies and policy development based on publically held values in combination with expert knowledge that local communities are more likely to accept and support (Alessa, Kliskey and Brown, 2008). Community attitudes to shark management are complex and multifaceted, and influenced by local contexts, density of human population, lethal or non-lethal nature of management actions, as well as personal experiences, risk perceptions, characteristics of certain species such as the Great White Shark, and sensationalised media coverage of shark incidents (Taylor, McLean, Korner Glozier, 2019; Simmons and Mehmet, 2018; Gibbs and Warren, 2015; Crossley, Collins, Sutton and Huveneers, 2014; West, 2011). SMS-related social research conducted to date includes a social media analysis (Simmons, Mehmet and Clarke, 2017) and two telephone and parallel online surveys in the Ballina area on the Far North Coast (NSW DPI, 2017, 2018a). We also ran focus groups at several coastal locations in which community members with different beach and ocean interests discussed various SMS shark mitigation approaches (NSW DPI, 2018b). Data collected have provided important insights into community attitudes, support and preferences for different shark mitigation approaches including SD.

General findings to date indicate shark risk in most NSW coastal regions, other than the Far North Coast, was largely considered low since sharks were not perceived to be an issue. However, there has been some consensus that shark mitigation was justified to help people feel safer, especially in more densely populated areas and among visitors and tourists, which was seen as important for areas dependent on tourism. Support for different shark mitigation approaches varied. Generally, those surveyed strongly opposed using nets due to socially unacceptable levels of bycatch/mortality and ineffectiveness at catching target sharks. However,

there was greater support for nets on the Far North Coast. The need for shark mitigation was considered high in view of the number of shark incidents in recent years, particularly among local surfers who were more tolerant of bycatch due to increased feelings of safety with nets deployed (NSW DPI, 2018a and 2018b).

SD have been considered a better option than nets for minimising harm to sharks and other species, and for tagging and research purposes. However people largely perceived them as an ineffective shark mitigation tool – since they take just one shark at a time, and sharks are released and can return. An exception to this has been the Far North Coast, where SD were valued for their effectiveness in catching/relocating more target sharks compared to nets. This was a process perceived to deter sharks from returning, reducing the chances of human-shark interactions occurring. Most other coastal regions did not feel there was a need for shark mitigation using SD since sharks were not perceived to be an issue, especially on the South Coast in Bega Valley where SD trials were perceived to heighten anxiety about sharks in the community. There were also concerns about the welfare of sharks during the tagging/relocation process. In all regions, there were concerns that baited SD hooks would attract sharks to otherwise shark-free waters.

While there has been general support for helicopter aerial shark surveillance, most people saw this as more expensive and less environmentally friendly than drone shark surveillance. Further, due to the sporadic nature of helicopter flights, it was not seen as effective at mitigating the risk of human-shark interactions. Drone surveillance was preferred rather than helicopter surveillance as the former was more localised, cost-effective and non-invasive and can be incorporated into beach safety operations at patrolled beaches. There has been support for listening stations to detect tagged sharks, mainly for research purposes to track tagged sharks, and for issuing alerts helping beach management ensure public safety. However, overall effectiveness as a shark mitigation tool has been criticised since it was impossible to tag and track all sharks, and the limited lifespan of tag batteries prevented long-term detection and tracking of tagged sharks.

While some people said they supported the SharkSmart App as helping beach management increase public safety, it has been widely criticised for its inability to help people at risk in the water, lack of local and specific information, and multiple alerts that were perceived to heighten fear of sharks in the community. There has been strong support for shark mitigation involving educating people to be SharkSmart (especially visitors and tourists) to take personal responsibility for their safety.

Social research to date has provided useful insights into community sentiment for different shark mitigation approaches. However, this has been limited to a few locations and further research is needed to assess community attitudes in other areas, including Newcastle, Sydney's Northern Beaches, and the Far South Coast (Bega Valley shire), where SD trials have recently ended.

Before starting these SD trials, community engagement and communication activities were undertaken in trial areas to raise awareness and inform the community about impending SD trials. This included local council and key stakeholder briefings, media releases, beach signage (appendix 1), and social media communications, as well as community drop-in stands (appendix 2) allowing the general public to informally discuss the SD trials and voice concerns. Newcastle and Sydney communities largely supported the SD trials. Many people who were initially apprehensive or opposed to SD said they had changed their minds after

receiving information at the drop-in stands explaining how SD operate, but a few remained opposed due to perceptions SD trials were a waste of money since sharks were not an issue in the area.

The proposal for an SD trial on the Far South Coast was a very contentious topic, with most respondents (57%) in a pre-trial online survey (n=237) that canvassed community views indicating they did not support the trial. This was mainly attributed to perceptions SD would intrude on the sharks' habitat or that SD trials were an unnecessary waste of public money since shark mitigation was not needed in the area. Most survey respondents were not concerned about the risk of shark bites at beaches. In contrast, respondents who were supportive (43%) said they felt the SD trial would be good for shark research purposes and have a positive impact on perceptions of safety, benefitting tourism in the area. A further survey run by ABC South Coast (n=507) found most respondents (66%) did not support an SD trial. In response to the opposition, NSW Department of Primary Industries (DPI) held community consultation sessions with the Far South Coast community to inform residents about SD. Many residents were more supportive of SD trials after receiving this information. Subsequently, with support of the Bega Valley Shire Council, the decision was made to run a two-month SD trial.

3 PURPOSE AND RESEARCH QUESTIONS

3.1 PURPOSE

To explore community attitudes and perceptions related to shark risk mitigation following trials of SMART drumlines in the Bega Valley, Newcastle, and Sydney regions.

3.2 RESEARCH QUESTIONS

What are the attitudes of beach and ocean users to shark mitigation since trials of SMART drumlines?

Sub-questions:

What are attitudes to, awareness of, and perceived advantages/disadvantages of:

- i. in-water shark management approaches - SMART drumlines and mesh nets?
- ii. aerial shark surveillance - helicopters and drones?
- iii. technology and monitoring - VR4G listening stations and associated tagging, the SharkSmart App, and personal deterrents?

4 RESEARCH METHOD

4.1 FOCUS GROUPS

This study used focus groups to explore attitudes and thinking concerning In-water Management (SMART drumlines, mesh nets), Aerial Surveillance (drones and helicopters) and Technology and Monitoring (VR4G, SharkSmart App and Personal Protection Equipment). Importantly, in focus groups, people are encouraged to listen to other opinions as well as express their own. They are a tool for studying groups with a perspective of special interest, and for developing insight into the range, depth and thinking on the focus topic(s). On their own, focus groups are not generally intended to be representative of large populations as a randomised survey study would. The findings tell us how and what people think, but not how many think this way, so we need to take care about generalising insights to wider populations. The participants in this study were people with an interest in the coast, including recreation, business, safety and environmental protection stakeholders.

Focus groups tend to be chosen for studies of attitudes and behaviours that are not socially sensitive, that is, topics that participants were likely to feel comfortable discussing in front of others. Focus groups were used here to explore specific topics of research interest, bringing together different perspectives to compare and contrast attitudes and experiences (Patton, 2015).

The researchers took particular care to create discussion environments that put people at ease. This included the selection of venues and participants, the advance information provided, the structured approach to questioning, soliciting each participant's perspective, and promoting a confidential and non-judgmental ethos. A discussion guide (see Appendix 3) was designed to allow participants to feel valued, to feel comfortable in expressing their opinions, and to reduce the potential impact of group influence on the expression of individual attitudes. Participants were assured that transcripts would be de-identified and reports would not include the names of interviewees. The researchers gained ethics approval (protocol number H16172) on 3 May 2019 from Charles Sturt University's Ethics in Human Research Committee.

4.2 DATA COLLECTION

Ninety-minute focus group discussions were held in surf lifesaving clubs in May and June 2019. The five sites along the NSW coast were:

- Bega Valley - Tathra
- Bega Valley - Pambula
- Newcastle
- Sydney Northern Beaches (Avalon); and
- Sydney Northern Beaches (Freshwater).

The chief investigators led each discussion.

4.2.1 Sampling

We were interested in people's attitudes to shark management generally, in-water Management (SMART drumlines, mesh nets), aerial surveillance (drones and helicopters) and technology and monitoring (VR4G, SharkSmart App, personal deterrents), as well as local or other contextual influences on attitudes.

Our sampling approach was similar to Gibbs and Warren (2015) who targeted ocean users with a survey. We gathered a sample tailored to the research's purpose, rather than a random sample (Krueger and Casey, 2014). We sought participants with an interest in the ocean as users, as advocates for its conservation, or as people who perceive livelihood benefits. Although their perspectives differ, they have in common some special interest in or experience of the ocean.

We elected to gather groups of ocean users in each of five areas around SMART drumline trial sites, rather than separating the groups by interest (ie a surfer group, a conservation group, etc.). This sampling approach was also guided by Patton's (2015) evaluation and diversity-focused varieties of the group discussion approach to research. With groups that were diverse rather than homogenous, we were particularly attentive to the potential for groups to be dominated by people with more detailed knowledge, people from the small community catchment areas having prior relationships, and participants inclined not to speak if they perceive their views were in the minority (Patton, 2015). To prevent some of these potential barriers to full and frank exchange, the interview design included deliberately setting up inclusive and non-judgmental ground rules at the start, and multiple turn-taking round-table questions.

The criteria for inclusion in the sample were:

- Aged 18 or over;
- Live or work within 30kms of centre;
- Be users of and/or interested in the ocean for recreation, business or conservation: Beach and ocean swimmers, surfers, divers, anglers, marine environment and coastal conservation, paid lifeguards, volunteer lifesavers, tourist operators and small business; and

Excluded were DPI employees and individuals with a vested interest in a particular mitigation strategy.

4.2.2 Recruitment

The main approach used to identify eligible focus group participants was online searching. An assistant used the Internet and telephone to research and develop contact lists for local (beach and ocean user) individuals and groups. The key search terms used were the name of towns and regions, plus entity type (club or association or society) plus user type (board rider or surf lifesaving or ocean swimming or chamber of commerce, etc.). Also used was snowball sampling, where contacts were asked for names of other contacts who met the recruitment criteria. A list of potential participants was generated and then individuals were contacted by email and phone using standardised scripts for consistency in briefing and background information. Each focus group participant was given a \$60 incentive at the end of the discussion. The target sample size for each group was eight to 10 people. Due to a consistent 'no-show' rate of 20-30% in this type of research, recruitment stopped once 12 of the target user groups had agreed to participate.

4.2.3 Sample

The sample is profiled for each group in Table 1.

Each group included a cross-section of beach and ocean users as planned. Participants included people with professional and amateur/recreational interests in the ocean. Importantly, all groups contained a substantial number of users who actually go into the water. Each group had at least four surfers, and four beach and ocean swimmers, and one person from tourism/small business. There were 33 males and 14 females. Twenty-one participants were aged 18-45 while 26 participants aged 46 years or older. For each group, about one in four people who agreed to take part did not attend. This attendance rate is consistent with other similar projects with members of the public.

4.2.3.1 Table 1: Focus group participants

		Tathra	Pambula	Newcastle	Sydney (Avalon)	Sydney (Freshwater)	Total
1. Gender	Male	5	6	8	6	8	33
	Female	3	4	2	1	4	14
2. Relationship to ocean	Angler	2	3	0	2	2	9
	Surfer	5	7	7	5	4	28
	Beach / ocean swimmer	5	7	5	4	9	30
	Kayaker / stand-up board	3	4	1	2	1	11
	Tourism / business	4	4	2	4	1	15
	Conservation/ environment	3	4	0	2	5	14
	Diver	3	4	1	1	6	15
	Lifesaver	3	2	6	0	4	15
	Other	0	5	2	0	1	8

3. Age	18-25	0	0	2	1	1	4
	26-35	1	4	0	2	2	9
	36-45	2	1	0	1	4	8
	46-55	2	2	3	1	4	12
	56 plus	3	3	5	2	1	14

Note: Many participants had multiple interests in and relationships with the ocean

4.3 DISCUSSION GUIDE

4.3.1 Line of questioning

Group discussions among beach and ocean users were used to listen to both the 'brain and the heart' (Krueger and Casey, 2014). Many say that shark fear and emotions were disproportionate to the statistical risk. It was important to find out what people think about shark management in detached and logical ways, and also to find out how people feel.

Following Krueger and Casey (2014), we used several stages to develop the questioning for the discussion guide. The project research questions necessarily drove the design of the discussion guide. The research questions required data to be gathered for seven shark management strategies across three broad categories of approach for each of five trial sites. This is a large number of questions and topics for a qualitative study of this kind. The discussion guide was more tightly structured and timed than might often be the case with focus groups.

The investigators reflected on the research questions and topic under study, and then brainstormed a set of questions. The chief investigator then spent time refining the phrasing of the questions and creating a sequence that funnelled logically from a broader context to the specific topics of interest. The group again met to review and align the discussion questions with the project research questions. The questions went through several iterations of review and amendments, see the discussion guide in Appendix 3.

A sequence of questions was standardised across the groups (Patton, 2015). To break the ice and introduce participants, an easy, factual question was asked first to encourage participants to talk about ways that they use the beach and ocean before asking for opinions (Patton, 2015) on the specific strategies of interest (Krueger and Casey, 2014). The interviewers were mindful to use open-ended questions in the early stages, and avoid questions that might be likely to lock participants into certain attitudes they may feel they need to maintain and justify. Most questions were open-ended in ways that encouraged participants to 'determine the direction of the response' (p53). That is, these questions reveal what was on the interviewee's mind, not what interviewers expect was on their minds (p53). '[O]penness of inquiry' in questioning and researcher mindset helps to uncover unanticipated outcomes of programs (Patton, 2015, p11/12). Simmons and Mehmet (2018) have argued that policymakers can benefit from insight into unintended consequences of shark management strategies. Insights into the unintended consequences of policy help to complete a more nuanced picture, and may help authorities to better target communication and other action options.

The different categories of shark management strategy (in-water, aerial surveillance, technology and monitoring) were each introduced and discussed, in turn, for about 20 minutes. Group awareness was briefly and broadly gauged for each of the seven strategies of interest (SMART drumlines, mesh nets, drones, helicopters, VR4G, SharkSmart App and personal protection equipment), before each strategy was explained with the help of photos, diagrams, and infographics presenting the catch data for the recent local SMART drumlines trial.

To end the discussion, each participant was asked to discuss whether the recent trial of SMART drumlines had influenced their attitudes to beach and shark management in the local region.

4.4 CODING AND ANALYSIS

4.4.1 Coding

The first of several stages of data processing occurred during focus group discussions where the investigators made notes. Within two hours of the completion of each discussion, the interviewers' notes were then used to identify and record salient topics, associations and justifications. The researchers coded collaboratively to enhance accuracy and consistency (Saldaña 2015). The discussions were also taped and transcribed.

The researchers drew frequently from four *Affective* coding dimensions (which Saldaña [2015] recommended for use in sentiment analysis) simultaneously, to develop an understanding of themes likely to motivate action, reaction and interaction:

- Values coding reflected on participants' values, attitudes and beliefs representing their perspectives or worldviews;
- Emotion coding was used to report feelings and reactions to experience and actions, and events;
- Versus coding identified individual and group preferences for mitigation in dichotomous or binary terms, especially by comparing with other strategies; and
- Evaluative coding assessed the judgements about the merits, worth, or significance of programs or policy (Saldaña, 2015).

4.4.2 Analysis

The analysis was performed in three stages. Due to a large number of mitigation strategies reported along several dimensions across five trial sites, there was extensive use and refinement of matrices over research stages to aid analysis. The insights from affective and basic themes coding were negotiated between coders to identify higher-order and meta-themes. These themes were used with verbatim quotes to develop narratives presented as the findings. The findings explain thinking associated with in-water management (SMART drumlines, mesh nets), aerial-surveillance (drones and helicopters) and technology and monitoring (VR4G, SharkSmart App and personal deterrents). To enhance consistency of analysis across all focus groups, the researchers collaborated again to determine responses to the research questions presented in the discussion, conclusions and recommendations.

5 FINDINGS

The purpose of the study was to explore community attitudes and perceptions related to in-water Management (SMART drumlines, mesh nets), aerial surveillance (drones and helicopters) and technology and monitoring (VR4G, SharkSmart App and personal deterrents).

The findings are first presented by trial site:

1. Bega Valley - Tathra (section 5.2);
2. Bega Valley – Merimbula - Pambula (section 5.3);
3. Newcastle (section 5.4);
4. Sydney’s Northern Beaches – Barrenjoey to Newport (section 5.5); and
5. Sydney’s Northern Beaches – Dee Why to Manly (section 5.6).

The discussion section then reports across the sites against the three project research questions stated in section 2.2.

5.1 KEY TO IDENTIFYING FOCUS GROUP COMMENT SOURCES

Verbatim quotes from focus groups are attributable to the towns where discussions took place, using the following key:

Tathra = TP

Pambula = P

Newcastle = N

Avalon = A

Freshwater = F

In each focus group, the participants introduced themselves and their association with the coast. Participants were numbered in the transcription and are referred to as follows (for a Tathra example): T (Tathra) P2 (participant 2) = TP2.

5.2 BEGA VALLEY – TATHRA

5.2.1 In-water shark management (SMART Drumlines and mesh nets)

5.2.1.1 Table 2: Tathra in-water shark management findings

	Advantages	Disadvantages
SMART drumlines	<ul style="list-style-type: none"> • Research through data gathering • More humane than nets (sharks not generally harmed) 	<ul style="list-style-type: none"> • There is a low risk in the area. SDs make sharks more salient than they should be • SDs demonise sharks (implying that they want to attack us) • High cost for low research gain (tiny number tagged)
Mesh Nets	<ul style="list-style-type: none"> • Make some people feel safe (good for tourism but not based on results) 	<ul style="list-style-type: none"> • Antiquated approach • Cruel • Waste of resources

Participant preferences, reasoning and other comments

All participants were aware of SMART drumlines and mesh nets to some extent. Both in-water measures were deemed inappropriate for this area with local residents saying they preferred newer technological solutions. SMART drumlines (SDs) were seen overwhelmingly as a research strategy, not to mitigate harmful interactions. Some participants questioned the timing of SD use during the trial, stating that sharks often feed when the SMART drumlines were out of the water.

It's all good for further understanding and research into their movements, but what if they [SMART drumlines] were just out there at the wrong time? (TP5)

There was a strong economic theme arguing that the return on investment did not warrant the harm to sharks, and that they potentially work against economic interests.

... the whole effort a waste of time and money. (TP1)

Those involved with tourism commented that the sight of the buoys was a reminder to tourists that sharks 'may be in the area'. Some supported this perception saying they believed it was better not to know, that out of sight means out of mind.

It's just like a reminder that they're out there. (TP8)

Although not used in the local area, the group also discussed the use of mesh nets as a shark management strategy. They believed that mesh nets were only useful for comforting 'the ignorant' (e.g. inexperienced tourists). There was a general consensus in the group that mesh nets were a cruel, outdated and antiquated mitigation measure that should be consigned to the past.

It gives people a false sense of security ... to have a net offshore that is supposed to capture a dangerous shark in a 150m parallel net. In that way, it is supposed to stop a big shark swimming into shore, it doesn't. So yeah, it's stupid, antiquated and old hat. (TP4)

5.2.2 Aerial surveillance (drones and helicopters)

5.2.2.1 Table 3: Tathra aerial surveillance findings

	Advantages	Disadvantages
Drones	<ul style="list-style-type: none"> • Good for rescues and general water safety surveillance • Minimizing risks to lifeguards • Lower cost surveillance – can spend more time surveying • Multipurpose water safety tool 	<ul style="list-style-type: none"> • Condition dependent • Privacy concerns • Noise and visual pollution • Small coast range
Helicopter	<ul style="list-style-type: none"> • Large coverage area • Hopefully assist with rescue • Can hover and drive sharks out to sea 	<ul style="list-style-type: none"> • High cost for low return • Condition dependent • Requires land personnel support

Participant preferences, reasoning and other comments

All participants were aware of drones and helicopter surveillance, but not necessarily the protocols and routine practices, or the entities responsible for delivering these services. Newer drone technologies were preferred to older ones. The primary motivator for this was the amount of air time drones could spend above swimmers, and advancements in drone technology.

They [helicopters] fly too fast, but they can't obviously do it too slow. But it isn't like a drone where you put a drone up and surveil the area. (TP4)

Although the use and effectiveness of aerial surveillance (both drones and helicopters) depend on water and weather conditions, drones were considered advantageous in terms of cost. This was because they increasingly served multiple purposes as a tool for water rescue support generally (but especially drownings), as well as surveillance. Helicopters were considered to be poor value for money, despite covering larger coastal areas.

5.2.3 Technology and monitoring (VR4G, SharkSmartApp and personal protection equipment)

5.2.3.1 Table 4: Tathra technology and monitoring findings

	Advantages	Disadvantages
VR4G	<ul style="list-style-type: none"> Tracks tagged sharks (some better than none) 	<ul style="list-style-type: none"> Only tracks tagged sharks (not enough to make much difference for beach safety) Visual reminder of shark presence in area
SharkSmart App	<ul style="list-style-type: none"> Awareness of sharks gives some personal control of risk Good for tourism and event operators with water-based clientele 	<ul style="list-style-type: none"> App is annoying - it goes off so often App deters people from water/changes behaviour They alert but don't suggest action
Personal deterrents	<ul style="list-style-type: none"> They reflect that sharks are about personal responsibility They give people a sense of security Good placebo 	<ul style="list-style-type: none"> Better ones cost too much Low risk, high-cost ratio Effectiveness unknown

Participant preferences, reasoning and other comments

All but a few of the participants were aware of the VR4G and SharkSmart App, with about half of them aware of personal deterrents. There was confusion between Dorsal (the community-based shark alert app) and SharkSmart App among some participants.

Are you talking about Dorsal, is that it? It would be using the app, so that, I guess ... but we've got that yellow buoy at Merimbula that just annoys me. (TP8)

Preference was largely individual and according to perceived need. The app and personal deterrents, in particular, were considered useful for those who wanted them (however, proven functionality of personal deterrents would need to be improved for most to support). Personal responsibility was a popular notion, with all participants saying it was up to each individual ocean user (or responsible guardian) to be educated on beach and ocean safety, including sharks.

Ah, a shark going past, being spotted in the local area. The only thing is the nearest one [listening station] is down at Merimbula and we are here at Tathra. So, the proximity of where the sensors are, it doesn't really help for such a vast piece of coastline... Just looking into the app, just from what (TP5) was saying just then, that it gives you a resource to go to, does that negate your responsibility for being aware, because you have this safety device that is supposed to tell you when sharks are there, so you neglect to be aware of your surroundings? (TP3)

The potential of the app to provide information about the whereabouts of sharks can influence decisions about where or where not to enter the water. Sometimes the alerts can irritate if they are perceived to be irrelevant or infrequent, but the app appeals to some people operating businesses and events because it helps provide a sense of control over client safety.

It gives us a better sense of being safe, so if the app does go off, whether it's been spotted by a drone, whether it's been spotted by a buoy or a helicopter, we know that okay, there is that risk. We might change the location that we go to, or we might cancel the activity. We've had to cancel surf lessons or have surf lessons cut short down at Pambula because of the drone spotting the sharks down there. (TP5)

5.3 BEGA VALLEY - PAMBULA

5.3.1 In-water shark management

5.3.1.1 Table 5: Pambula in-water shark management findings

	Advantages	Disadvantages
SMART drumlines	<ul style="list-style-type: none"> • Good for research • Good for shark population • Mitigation <u>not</u> mentioned 	<ul style="list-style-type: none"> • Indiscriminate with non-targets • Cruel for catch • Visible buoys increase fear
Mesh nets	<ul style="list-style-type: none"> • The unaware feel safer 	<ul style="list-style-type: none"> • False sense of security • Too much bycatch • Waste of money, high maintenance

Participant preferences, reasoning and other comments

All participants were aware of SMART drumlines and mesh nets. All group said that SMART drumlines had a research role to play in the Pambula region. Some felt their presence reassures some inexperienced beachgoers.

Well, I am very much in favour of these drumlines because I think the more research we do on sharks the healthier our attitude and the more accurate our performance will be in managing our sharks. You can't manage a shark unless you catch it and tag it. (PP8)

Participants approved of the attempt to keep sharks alive, rather than cull them, but there was wide-ranging criticism of SMART drumlines. They said that the experience of being hooked and tagged would still be highly stressful for sharks. They questioned accounts of releasing 'huge' Great Whites and the effectiveness of contractors, arguing that it was unlikely just two people could handle sharks of the sizes reported. They questioned the effectiveness of contractors and were concerned that the hooks would not discriminate between target sharks and other marine life. Some of the surfers in the room felt that it was wrong to attract sharks to a bait close to humans in the water, and believed setting up baited hooks should be in 'shark zones' and not people zones.

Whether it be a shark or be other marine life, and there could be a bycatch, and a struggling bycatch could attract a predator shark. So, without the bait being there, there's no rationale for the shark to be attracted to it because it's not there. They claim that they're only passer-by sharks, and if they're passing by, I find some of that a bit speculative. There was a lot of concern in the community when they were put out, particularly out the back of the Merimbula Bar, because the Merimbula Bar is the take-off zone for the surfers which is about 250-300 metres from the shore, and then another 150m out the back is this buoy with the baited line sitting there within a reasonable close proximity. When you are in the water looking at them, they look like they're very, very close and that you could paddle to them in a matter of minutes. (PP9)

Although some 'uneducated' tourists might be reassured, participants said they believed mesh nets offered a 'false sense of security' so didn't support them. The group felt that nets resulted in much unwanted bycatch causing an ethical dilemma. Many explained their dislike of nets with reference to wasting money and ineffectiveness [at catching target sharks]. Many said they believed newer technologies were needed and renounced the need for nets.

I think if simple-minded people who don't use the ocean frequently come down I think a lot of them would actually go swimming where there was a shark net, because of the fact that there is this false sense of security. Um, and I am talking about people, the tourists in different areas and things like that. There are no other advantages, other than it looks probably good for somebody, it ticks a box, which we are all used to, in everything we do. Um, disadvantages, everything that has been said already, and again, you know, it is definitely ... we've moved on from shark nets, I think. As you said, did you say the '30s or something? (PP5)

Some were concerned that repeatedly leaving the bait in an area near people in the water invites sharks to the area and creates danger unnecessarily. This was particularly the case of surfers who paddled beyond the breakers. Others felt sharks would be likely to swim right past a hooked mullet and continue to the beach.

Participants said they believed that although 'sharks have always been here', sharks were not a problem. They felt that all the attention created by a SMART drumlines trial was creating an impression that the 'problem' was bigger than the reality. They saw no reason for a trial in the region.

5.3.2 Aerial surveillance (drones and helicopters)

5.3.2.1 Table 6: Pambula aerial surveillance findings

	Advantages	Disadvantages
Drones	<ul style="list-style-type: none"> Valuable multipurpose tool Noninvasive Can be automated 	<ul style="list-style-type: none"> Can create too many alerts and fear Not durable, expensive to replace Noise pollution Condition-specific
Helicopter	<ul style="list-style-type: none"> Superior image of sharks 	<ul style="list-style-type: none"> High cost Ineffective Sight and sound pollution Condition-specific

Participant preferences, reasoning and other comments

Awareness of both drones and helicopters was high across the focus group. Participants supported the concept of monitoring from the air as a logical approach to surveillance. All participants said they preferred drones. Their reasoning centred on drones' capacity to meet site-specific requirements across time and space, cost-effectiveness, and the potential for future advancements in drone sensory, automation and other performance capacity. Drones were valued as a multipurpose safety tool at the beach, and as a non-invasive shark harm mitigation strategy. The infrequent nature of helicopters meant that drones could be where swimmers and surfers were more often.

I think they are a really great idea, just what everybody has already mentioned, to be able to survey an area. But I think that for swimmers I am a bit two-sided about it. Part of me thinks I would like to know, but as (PP7) was saying, if I am in there and I saw that there are sharks, because there are sharks in the ocean, I am just going to freak myself out and not want to go swimming. But that is down to what I know about sharks as well. So, I don't know, I think not knowing is probably better. Especially because the risks are so low, generally! (PP4)

And the fact that it is [helicopters] only one moment in the day. If you're out in the surf and it flies over you, that's it for the day and you go, oh well, beauty, see you later. (PP8)

But with the drone it is every hour or every half hour or something that the thing buzzes. (PP1)

Drones were also preferred to SMART drumlines

Obviously in terms of the other two methods, drones are much better, because there is no bycatch or death or anything like that. (PP4)

5.3.3 Technology and monitoring

5.3.3.1 Table 7: Pambula technology and monitoring findings

	Advantages	Disadvantages
VR4G	<ul style="list-style-type: none"> Yellow is a good colour (stands out more than red) 	<ul style="list-style-type: none"> Need good land back up Only tracks tagged sharks
SharkSmart App	<ul style="list-style-type: none"> Can see where sharks are 	<ul style="list-style-type: none"> Not helpful out in water Too many alerts scare people
Personal deterrents	<ul style="list-style-type: none"> Puts responsibility back on individual 	<ul style="list-style-type: none"> Too expensive Uncertainty about effectiveness Unintended shock risk to humans and marine life

Participant preferences, reasoning and other comments

Awareness of the three approaches was high for all but one participant. All group participants said they felt that it was important for people to take 'personal responsibility' at the beach, and generally supported the dissemination of better information and advice to help people to make informed decisions about their ocean use. There were no clear preferences among the technology and monitoring strategies - each was considered to have some merit and some shortcomings. Participants were sceptical about the effectiveness of the app and VR4G. This was because they only identify tagged sharks and because effective shark harm mitigation using the VR4G and SharkSmart App required very good land back up to provide timely alerts to help people in the water. The VR4G was viewed as a tool for research rather than beach safety.

From a research perspective is great, to see where they're moving, how far they're moving, when they are coming in close to the coast and when they are absent. (PP8)

Personal deterrents were supported for emphasising personal responsibility in the ocean, but little was known about how confident to be that they are effective in deterring sharks. Some participants believed there was an ethical question that needs to be answered in relation to deterrents, that of using electronic measures to shock and thus deter sharks.

And then ... you've got like your harmless sharks that it's just going to potentially impact your Port Jacksons or your stingrays or something ... in an area where you know, you don't understand or know what that impact is, I suppose? (PP4)

Overwhelmingly the groups preferred education as an approach to informing beach users about safety - 'change people, not sharks' one person said - and more research to improve knowledge and conversation about sharks.

We should be focusing on educating people on how to swim in the ocean and what's in the ocean, instead of ... we've talked about how people are scared of sharks, but it is so infrequent. So maybe we need to address that before setting something up that is just going to cause so much destruction (PP6).

5.4 NEWCASTLE

5.4.1 In-water shark management

5.4.1.1 Table 8: Newcastle In-water shark management findings

	Advantages	Disadvantages
SMART drumlines	<ul style="list-style-type: none"> • Shark lives • Tagging helps research and understanding • Mitigation not mentioned 	<ul style="list-style-type: none"> • Very fallible system • Too costly • Not effective, need too many to make a difference
Mesh Nets	<ul style="list-style-type: none"> • Stats show they are proven to limit shark attack • Add to safety of humans 	<ul style="list-style-type: none"> • Too much bycatch • Too labour intensive • Ineffective • No useful data

Participant preferences, reasoning and other comments

All the group participants were aware of both in-water mitigation approaches. There was a clear preference for non-lethal approaches to shark mitigation and a clear preference for SMART drumlines rather than nets. However, the group were divided on attitudes to SMART drumlines. Some members believed they proved 'useless' because of the low number of target species caught during the trial, while others liked the idea of catching sharks and taking them away from populated areas.

I think it's a good idea. It's a lot better than the nets. (NP5)

I think it's great that they're not just jumping in straight to wanting to kill them. I think it's good that you take them back out to shore once they've been on the hook. (NP4)

Um, but I don't necessarily ... I don't think we need them. (NP2)

Most felt that it was foolish to use a baited hook to attract sharks to areas where people surf and swim, and that far too many to be affordable would be required to make a difference. Although most participants believed more knowledge about sharks was needed, and support for research was strong, they would prefer the DPI explores alternative means of tagging sharks. Participants did note, however, that they believed the area was not suitable for the SMART drumlines trial, as they did not see the region as having a shark problem.

Definitely a positive, if you are going to have a tagging process, that's a good thing. We did have, the juveniles were tagged off Stockton Beach for many years, through CSIRO. Which I thought was a great idea, because the more tagged sharks you have, the more you can keep an eye on them. The disadvantage is that it is indiscriminate, you are not going to catch everyone. The other thing I see as a downside is attracting sharks to bait, to any area where there is humans is not a good idea, I've heard. That's my belief, anyway. (NP9)

One member of the group said that decades of low shark attack statistics indicated that mesh nets had been proven to be effective. Not everyone in the group viewed mesh nets positively. One participant preferred an array of shark mitigation approaches, and said SMART drumlines and nets could work together. But even the supporter of nets said they had deep concerns about the environmental impact of in-water shark management.

A net is not a solution, and neither is a drumline in isolation, but together, they work together with added aerial surveillance and lifesavers and public awareness... for me, [the problem] would be that the bait they use on the drumline is not only attractive to sharks, but there would be a bycatch that worries me. (NP8)

The main reasons participants gave for opposing nets centred on the false sense of security they offer and the fact that marine creatures of all shapes and sizes had to die. Also, there was no research value to nets, and there was no data (except for mortality rates) that can be used to better manage beaches or the small risk of a shark encounter.

I don't like how they're indiscriminate [killers], and also there is no learning involved. The shark gets caught, the shark dies. We don't learn anything more about sharks. However with the other methods, we can tag them and we can learn a bit more about the sharks. (NP10)

5.4.2 Aerial surveillance (drones and helicopters)

5.4.2.1 Table 9: Newcastle aerial surveillance findings

	Advantages	Disadvantages
Drones	<ul style="list-style-type: none"> Valuable tool for surf rescue and shark surveillance Cost-effective Becoming better and better 	<ul style="list-style-type: none"> Limited use in poor conditions Requires high-level training If you look for sharks you see them - too many alerts and closures
Helicopter	<ul style="list-style-type: none"> Cover large areas Cover unpatrolled beaches 	<ul style="list-style-type: none"> Expensive Don't help surfers Infrequent cover

Participant preferences, reasoning and other comments

Awareness was unanimous in the group. Participants preferred drones rather than helicopters because of the cost, efficiency and specificity of range. Drones' cost-effectiveness was raised in comparison with helicopters, which can cover large areas including unpatrolled beaches, and in relation to the high running costs of mesh nets/SMART dumlines contractors.

Well, it's very cost-effective, compared to say something like the Westpac helicopter if there's a shark sighting. It's probably a lot more open to training for the abilities of surf lifesavers, like a couple of courses or something like that rather than having to be a trained up pilot or someone to fly a helicopter. I think it's excellent. (NP4)

I think they are a very good thing, using the latest technology. They tend to be run with volunteer labour, and that's different from say the contractors which lay out the nets and set and check the drumlines. So, from that point of view, they are cost-effective. (NP5)

Other reasoning, however, was based on the continued evolution of the technology. Many participants said they foresaw huge advancements in drone technology to the point where Artificial Intelligence would enable autonomous flight and sighting of beach dangers, including sharks and people drowning.

In the future, I can imagine there would be autonomous ones that won't need an operator. They will just send a drone around and they will circulate around the beach, come back and recharge and go back out. So, you've got to be able to keep an eye on the fringe of the beach. (NP7)

Yes, this is just the beginning for drones. The next 10, 20 years, we will really work out what they are going to do. (NP5)

Finally, people noted the flexibility of drones as a justification for using them rather than other methods.

So, it's just technology you can use it for various purposes. (NP4)

5.4.3 Technology and monitoring

5.4.3.1 Table 10: Newcastle technology and monitoring findings

	Advantages	Disadvantages
VR4G	<ul style="list-style-type: none"> • Good for research and understanding sharks • Visibility can be reassuring 	<ul style="list-style-type: none"> • Not directional • Small area covered • Relies on good systems for alerts to be effective
SharkSmart App	<ul style="list-style-type: none"> • App helps people take responsibility 	<ul style="list-style-type: none"> • App requires authorities to trust and use for alerts to be useful • No good for surfers in water
Personal deterrents	<ul style="list-style-type: none"> • No positives offered 	<ul style="list-style-type: none"> • Waste of money • Not trusted

Participant preferences, reasoning and other comments

Most participants were aware of sonar tracking and the SharkSmart App, but not the VR4G by name. Their awareness of personal deterrents was mixed. Some people had a highly detailed understanding, while others were completely unaware that personal protection was even an option for shark safety.

Preferences in the group were complex, with participants seeing strengths in different options. Participants saw research as the main role for the VR4G:

I don't see any real advantage apart from collecting statistics and helping someone with their PhD. (NP6)

Some said they felt the app would help and encourage people to take personal responsibility in the ocean. Some saw value in the app because it could be linked to surf lifesaving, and be part of coordinated efforts for beach safety.

If it goes to a central coordination place where one of those things is pinged and it gets relayed to the lifeguards and the lifesavers on duty, on patrol at a particular time of day, I reckon that would be a great thing. (NP2)

The main reason people did not like the current personal deterrents available was they believed companies were preying on peoples' fear, and exploiting a small increase in shark activity for monetary gain. This distrust was based on what they believed were ineffective products, 'snake oil' selling as some stated. This group discussed the idea of government subsidies for deterrents and some felt it would be a complete waste of public funds.

Oh, I am very interested in it because I love a good joke and I think they're a good joke. The advantages of them are none. But I used to sample them with my peer group, where I surf at Bar Beach, I can think of 50 surfers who surf regularly all the time, any time of the day. Out of all that you're talking about there, none of them. We've never talked about it. We've never thought about it and none of us use it and for obvious reasons because it's a waste of money. I'd be probably disappointed if government got into this game of personal deterrents, and started paying taxpayers' money on this snake oil. I don't think it should happen. Let the private sector work it out, come up with a solution and prove that it works, and they pay for it, individuals can pay for it. I don't want governments spending money on it. They can spend money on much better things. (NP8)

But some did like the idea of non-lethal, non-invasive technologies that were effective.

I'm for non-lethal deterrents. Something that can give beach coverage, without killing the shark, without killing local wildlife and all of the other stuff that would be long term. (NP8)

5.5 SYDNEY - AVALON

5.5.1 In-water shark management

5.5.1.1 Table 11: Avalon in-water shark management findings

	Advantages	Disadvantages
SMART drumlines	<ul style="list-style-type: none"> • More targeted with less bycatch - sharks survive • Perception of government making waters safer • Part of comprehensive mitigation program • Enable research into sharks 	<ul style="list-style-type: none"> • Sharks distressed • False security • Ineffective mitigation • Expensive
Mesh Nets	<ul style="list-style-type: none"> • Work to make people feel safer 	<ul style="list-style-type: none"> • Ineffective at catching target sharks • Kill sharks and non-target species • False security ('placebo') – people don't understand • Outdated, obsolete • Expensive

Participant preferences, reasoning and other comments

Participants' awareness of in-water shark management was high. They preferred SMART drumlines, with negligible support for nets. Nets were seen as more of a public relations activity for governments wanting to be seen to be doing something than real mitigation. People in the group said they wanted smarter management practices that were pro-active, rather than reactive, and commended the government for trying something new with the SMART drumlines.

Minimise bycatch, so unlike the nets, there's a big advantage there. Great for governments, because they can be seen to be doing something which is better than doing nothing. Fantastic for governments, so really good politically. Probably good for easing a little bit of tension in people, so an advantage for swimmers to feel a little safer.
(AP5)

Participants were encouraged that the DPI appeared to be looking to move away from mesh nets. They made it clear that they were supportive of any non-lethal approach to shark management, but not 100% happy with the SMART drumlines. They were very clear in stating that SMART drumlines were *not* the final solution. While acknowledging the research benefits, they said wanted a more humane way to tag sharks that reduced their stress and suffering.

[I]t [SMART drumlines] enables some type of research, as in recording types of sharks, size and things like that. I think, yeah, research is a really good part of that ... just need a better way to tag 'em, so we don't stress or harm the shark. (AP7)

Some said that SMART drumlines removed sharks that were near humans, but doubts were raised about the effectiveness of SMART drumlines as a measure intended to mitigate harm from sharks.

I don't know. Are they nine-to-five sharks. Is that why they do it at day time? What about all the sharks at night? It seems sort of pointless, and they've got the drums out now and it's not shark time. Shark time is when the whales are coming ... It would be better if they did the shark study at peak shark time. (AP4)

It's very possible that a Big White or a Tiger or a bull [shark] swims right past the baited hook and straight into the beach, so it is a false sense of security. (AP4)

Participants did not see mesh nets as a viable option for the future. Table 11 shows more perceived disadvantages than advantages. The single salient advantage mentioned was that nets helped to make people feel safer, and that this suits the government. However, the group said this feeling of safety was false, and based on misunderstandings about nets. The group said nets were often perceived to span the entire beach, which was incorrect. Some said that nets were an outdated means of making beaches safer.

It's not an enclosed area, so it kind of like feels like pointless to even have them out there. (AP2)

The advantage has to be once again political. Keeping them in there makes people feel safer. That's big if you run a tourism business that surrounds people coming and swimming and feeling safe, that's a big thing. But apart from that, the massive disadvantages are a huge bycatch, well, a huge risk of bycatch of anything from invasive species to non-target species. Ineffective, don't even cover the whole beach anyhow, so it's a false sense of security. It's a placebo, that's all it is! (AP5)

I am confused as to why they are still there. But of course, politically it sounds really great and most of the people I know that are getting in that aren't fully informed about shark nets, they just have no idea what they look like and they don't even know whether they do cover the whole beach. (AP3)

Yeah, for sure. Even my parents, who've lived here for like thirty-five years, they're like what? It doesn't cover the whole thing. No! (AP3)

Participants did not believe that nets were checked regularly enough, contributing to deaths and suffering of both sharks and other animals.

... if you get a run of weather like this, in two days there is no way that they would go out. They can't. The insurance wouldn't even cover the boat out in that stuff. (AP4)

This group did not like shark nets. They wanted them all removed to improve the environment.

... like you said, 1937, there's been 90 years of progress in technology and our understanding of shark behaviour. I can't believe that we're still using the same thing. Yeah, the sooner we can rip them out, the better. (AP1)

Some participants said it would be in the best interest of the government to get ahead of the public opinion curve and act now to remove mesh nets.

I think the lack of ... understanding of what shark nets are and that they don't span the whole beach and stuff like that. I think because most of the public doesn't really understand them, nobody is going to kick up a stink about them. So, then the government is going to leave them there, because a lot of people come to the beach and feel safe. But yeah, I think that's part of the reason why they have been around for so long and we're still using them. Whereas I feel like if people were more educated about stuff and understood how bad they were, a lot more people would probably, you know, kick up a stink about them. (AP7)

5.5.2 Aerial surveillance (drones and helicopters)

5.5.2.1 Table 12: Avalon aerial surveillance findings

	Advantages	Disadvantages
Drones	<ul style="list-style-type: none"> • Non-lethal risk reduction • A multipurpose non-invasive tool • Good for alerts and for watching sharks move away from the beach • Tech will make them the best tool in future 	<ul style="list-style-type: none"> • Need ideal weather and water conditions • Require good software • Need well-trained humans; prone to human failings
Helicopter	<ul style="list-style-type: none"> • Instant alerts • Non-lethal risk reduction • Reassuring for some 	<ul style="list-style-type: none"> • Ineffective because of infrequent timing of patrol • Expensive • Miss a lot of sharks • Noisy

Participant preferences, reasoning and other comments

All participants were aware of both aerial surveillance approaches. The group appreciated aerial surveillance was non-invasive to marine life and water environments. Generally, they preferred drones rather than helicopters.

... if there was a choice between supporting one or the other, I would be going for the drone because it's more logical to me ... because it's cheaper, and you still have a human operating it, but you are not wasting petrol and you're not paying crazy amounts of money for a helicopter to be going. And it can be reserved for things like people actually in trouble, like SES or something. (AP3)

... they can also be multi-use, so they can drop a flotation device if someone is caught in a rip. So, drones can be really great for that as well. (AP1)

The main shortcomings of drones were that battery life limited their time in the air, and they were perceived to be ineffective when conditions were not ideal.

... they're over the surface looking at the surface, so if it's murky water then they can't see it, if a shark is there, they can't see it. If they fly over and they happen to miss it, they're not going to see it. (AP4)

... I guess you couldn't use it on windy days or when it's really intense weather? Unless it's a super sturdy drone, I don't really know that much about them. (AP3)

In addition to being non-invasive, drones potentially could be used more in research and to access and assess the effectiveness of other mitigation strategies in-water.

I think, along the unobtrusive lines is that if something is spotted you can track it for a while and not chasing it, you know, like with a jet ski or something. You can actually follow and do more on the research thing, see where it's going and like (AP3) said, what it's actually after and why it's there... it can help you watch how efficient other parts of your protection are. Like it can see how the sharks are reacting to the SMART drumlines. (AP5)

There was some feeling that drones have great potential to improve, and would become more widely useful and effective with time, possibly providing more automated support.

... it is the beginning of a possibility where maybe this could be a good situation for AI. There's the human factor at the moment, but if you could do it such that the software, using AI could start to spot things. (AP6)

Helicopters were considered advantageous in terms of providing instant alerts to the beaches they service, and while their hovering provides reassurance to some, others say it made them nervous.

AP2: I had one fly past when I was at home last summer, I was swimming with my son and it hovered over us, like literally hovered over us and five metres away there was a 3.8m Great White [Shark]. I got out and I talked to the copper pilot, and said do you know you just scared the bejesus out of everyone on the beach. He goes, yeah, I love it.

AP6: It would literally be hovering over people, seeing them ink like a squid, you know, everyone just crapping themselves!

AP2: They take their job seriously, but they don't mind scaring the pants off people.

Like drones, helicopters were perceived to require clear water to be effective. However, the high cost of helicopters, and the notion that you can buy multiple drones for a single day of helicopter use were participants' main arguments against the use of helicopters. Another disadvantage frequently raised relates to the infrequency of helicopter monitoring at beaches. Helicopters were believed to visit target beaches just once or twice a day and this was perceived to be too infrequent, especially when drones could be airborne as long as they have battery life.

it [helicopter] could be hovering over Avalon and then make its way to Whale Beach and the Great White [Shark] comes out. It's right on the beaches, there's no other forms of protection and alerts, the swimmers, surfers, they're all in trouble. I feel like when it's flying, it has got to be a pretty short amount of time that they hover over a beach to distinguish between a shark and a rock that's shaped like a shark, or a patch of seaweed or I don't know, just something that resembles a shark... the costs are ineffective, I think. I feel like I'd rather have three drones hovering over Avalon than one helicopter, I feel like that's just a better use of resources. (AP2)

Another important concern when compared to drones was the impact that helicopters had on local residents, with regard to noise and air pollution.

Helicopters do add would-be noise pollution. I know drones are pretty annoying and sound like mosquitoes in your ear, but I think helicopters are a bit worse and add pollution to the atmosphere. (AP7)

5.5.3 Technology and monitoring

5.5.3.1 Table 13: Avalon technology and monitoring findings

	Advantages	Disadvantages
VR4G	<ul style="list-style-type: none"> • Good for research • Non-lethal • Maybe reassuring for some swimmers 	<ul style="list-style-type: none"> • Not effective mitigation, too many not tagged • Not directional, not enough information • Not enough of them, leaving gaps along the coastline
SharkSmart App	<ul style="list-style-type: none"> • Meets the needs of the fearful (lots of alerts) • Can help with research and curiosity about sharks 	<ul style="list-style-type: none"> • Too many alerts of low relevance can be irritating and unhelpful • Not reducing risk • False reassurance or misinformed level of risk
Personal deterrents	<ul style="list-style-type: none"> • Can be reassuring • Can help in remote places away from help 	<ul style="list-style-type: none"> • False security • Expensive • Bad if they make you make bad decisions

Participant preferences, reasoning and other comments

Participants' awareness of VR4G was low, but higher for the SharkSmart app. However, the latter was often confused with Dorsal. There was a high awareness of personal deterrents, but a vague understanding of the concept and a poor idea about the specifics of the different types.

Participants said it was important to promote the notion of personal responsibility. They said that beach goers were entering the sharks' home and we should respect sharks. Beyond this, preferences were mixed. Due to the low number of sharks tagged, the VR4G was only seen as a research tool, there were too many untagged sharks for it to be effective mitigation.

I mean, for research it is great, if you can track the movement of an animal up and down the coast and learn a little bit more about that species, then yeah, I guess that is valuable learning. (AP1)

Participants saw as a limitation the absence of information about in what direction the tagged shark was headed.

So, if the sonar only goes 500 metres out, it's not directional, so it doesn't say what the shark is doing. It could be swimming around in circles or if it's heading out to sea, it's heightening risk without providing any solution to ... and it doesn't actually identify what level that risk is, whether it's a high risk or low risk. (AP5)

The app was seen as a double-edged sword: good for informing where tagged sharks were, but had a reputation for frequent alerts about sharks so far away the alerts were irrelevant. This potentially contributes to disproportionately high perceptions of risk of harm from sharks that was statistically low.

... it's like being a road user and getting an indication every time someone fails to use their indicator. It's an idea of oh, you might be in danger of having an accident. It doesn't ... it is just telling you that things are happening, but it's not telling you anything about your heightened risk. (AP7)

I feel like it's only telling us something we already know. Everyone here knows that there's sharks out there, we go out at our own risk. It's just kind of a constant reminder telling us something that we already know. (AP2)

Another reason people gave for dissatisfaction with the app was that the potentially heightened fear comes without a solution.

So, it's having a counterproductive effect, because it's not ... it's heightening fear without really making anyone safer in the water. (AP7)

It just scares the public, anyhow. You don't want it going bing, bing, bing all the time when you are going surfing, you want to put it out of your mind. I mean, it's good if you are really paranoid about it, but if you're really trying to put it out of your mind if you want to go surfing, you don't want to be going when there's 50 Tiger Sharks. No one will go out. (AP4)

Personal deterrents were seen as a viable option and some participants in the group favoured subsidies such as those in Western Australia. They argued it could assist those surfing in remote areas, although there was much doubt about their real effectiveness.

For people surfing in isolated beaches or swimming in isolated beaches, it is kind of like one of the best ways to be safe without anyone actually actively patrolling you. If you're surfing on a beach in Western Australia where there's no towns for kilometres, it's a good ... form of protection. But I don't know how protective it would actually be, if that makes sense. (AP2)

The advantages are you're self-protected, supposedly, and I guess it's also a placebo. You think you are protected, so you are more confident. (AP2)

So, I got, I think it was called the Shark Shield, and I got a bit of a primitive one that has been improved now. But anyway, so it made me feel safer. I think the advantage was it made me feel more comfortable going for a surf, psychologically. (AP6)

Again, however, the group expressed wariness of people not abandoning their personal responsibility to educate themselves about the risk of entering the water and understanding signs e.g. murky water, time of day. Some had bought a Shark Shield but abandoned using it due to it being heavy and awkward, and they feared being shocked.

The worry here in this situation is not talking about someone feeling better, which has a health benefit, but we're talking about someone falsely saying that they're in a position when they're not. So, it's very different to feeling better, which as we know, when we feel better our health improves so that you get actual chemical reactions in your brain and things happen in your body. If it makes you make false or bad decisions, and let's face it, the bad decisions around sharks are still for the most part... I can take you to places where I will give you almost 100 percent chance of getting taken by a shark. You wouldn't put on an electric device now and go, oh, I'm safe now, I'm going to jump in there, you know? But yeah, that is just different. (AP5).

But if your chances are one in two million in the first place and then you reduce that by a further 60 per cent. That's why I think the subsidies that WA offers, I think that's great. I think that's the most direct answer to people taking personal responsibility. (AP1)

Although there was general support for technology that monitors, detects and deters, the group emphasised that people still needed to take personal responsibility. They were concerned that people did not over-rely on technologies, that technologies have the potential to lead people to taking bad decisions.

5.6 SYDNEY - FRESHWATER

5.6.1 In-water shark management

5.6.1.1 Table 14: Freshwater in-water shark management findings

	Advantages	Disadvantages
SMART drumlines	<ul style="list-style-type: none"> Research function is advantageous 	<ul style="list-style-type: none"> Sharks are distressed unnecessarily Ineffective as mitigation Only purpose is for research, there must be a better way Value of data questioned Cruel way to get tag and get data Expensive
Mesh Nets	<ul style="list-style-type: none"> Reassuring for tourism and business Prevent large sharks from hanging around Long term association with low harm rates 	<ul style="list-style-type: none"> Too much bycatch Ineffective, they don't enclose Any reassurance is false security - PR exercise only Very expensive

Participant preferences, reasoning and other comments

Participants said they were all aware of the in-water shark management approaches. However, the level of knowledge of the workings of SMART drumlines and mesh nets varied considerably. For example, some said they believed the mesh nets spanned the whole beach, while others had only recently learnt they did not.

Being English, I was once a tourist who was sold the story of the nets, and when I found out the actual coverage of the nets and the reality of it, it actually made me really angry. I felt, I mean, it might be money, but I think it's that false sense of security. That really, yeah, pissed me off. (FP3)

There was a distinct general preference for SMART drumlines rather than mesh nets because of the reduced harm to non-shark marine life, and the data collected through shark tagging.

There was some minor support for SMART drumlines as mitigation but most participants in the group did not believe this location had a shark problem.

the only advantage I would see would be to collect data. But I don't see it as a beach safety method at all, (FP11)

Many in the group said they were very supportive of research that improves our understanding of sharks, and saw value in tagging. SMART drumlines were considered advantageous for their data-gathering function, which could be used to better manage the fishery long term. Thus, the support for SMART drumlines was based on a desire for the long-term sustainability of the marine environment, rather than mitigation of harm from sharks.

The data and everything is a really good thing and having a better understanding of the numbers and what beaches are more susceptible in areas and times of day, and all of that stuff can obviously provide a large benefit. (FP5)

But I agree ... the way they're tagging them by hooking them ... there must be a better way of doing that. But to start to understand how they work, I think that is the biggest thing. No one wants sharks to get killed or hurt in any way, but I think it just feels like there is no information about what is actually going on that the public actually understands. (FP7)

Some were very opposed to the use of SMART drumlines and questioned what the data was used for. Others said that if the tagging was the only reason for SMART drumlines, there must be a better way to get the data. The group raised many doubts about the use of hooks, which they perceived to be cruel, and questioned the 30-minute response time.

But I agree ... the way they're tagging them by hooking them ... there must be a better way of doing that. But to start to understand how they work, I think that is the biggest thing. No one wants sharks to get killed or hurt in any way, but I think it just feels like there is no information about what is actually going on that the public actually understands. (FP7)

I think there has to be other ways to get data than harming the animal, and I think that hooking something in its mouth, putting it through distress and pain is not worth it, and there has to be better ways. I also have massive concerns about the time in which those people get there. (FP4)

I am really angry that they just reach out for drumlines again, and I think it hurts sharks. I don't think it does any good at all. I think the actual tagging of sharks is a positive thing, but as we've discussed, there are other ways to tag sharks. They could use the same money for a tagging operation that just sends sighters out to put tags on sharks in different ways. (FP2)

But if they're going to do it, they have to find a better way to tag, because that tagging is just not, it's just not acceptable. It seems like a lazy way of doing it. (FP1)

They were also concerned about baited hooks attracting sharks to areas close to swimmers. To many, this seemed ineffective and potentially contributing to perceptions of a 'shark problem'.

If there's a two-metre shark on the end of the hook for half an hour, what's to say that a bigger shark isn't attracted to all the distress and comes and eats the smaller shark? It might be attracting larger sharks to the smaller sharks because they tend to eat each other. (FP10)

The low target shark catch figures for the Freshwater trial added to participants' scepticism about the design, appropriateness and effectiveness of SMART drumlines as a means of mitigation.

I guess you'd wonder how many sharks will just swim past a mullet without going for it. (FP5)

Although he said he would prefer non-lethal alternatives if they were available, one participant explained a case for mesh nets.

[Sharks are] more inhibited by the net, they are frustrated by it, they hunt at night and they don't want to stay there. That's the advantage that I've heard, and the other one though is statistics. You know, they've got really favourable statistics, New South Wales using those nets, in terms of the beaches that have nets and a lack of attacks. (FP6)

He said nets offered ocean users feelings of security that benefited business and the regional economy. This argument had little support, mostly from those whose businesses were tied to the ocean e.g. retail and hospitality.

I think the main advantage has been discussed already in the form of tourism. Not just tourism like everyone said, but even people from Sydney who aren't real ocean goers. The amount of shops that rely on people coming to Manly, or any district ... you take away the nets, and you take away a large chunk of that. But um, I am not, I can see a lot of people going oh, this guy is ... I am not for the nets right. (FP6)

The majority were critical of nets, concerned by their bycatch, cost and ineffectiveness.

The disadvantages is all the bycatch. It's terrible. Dolphins, small whales, turtles, endangered species. (FP6)

It is obviously a massive cost to check every net in the Northern beaches every two days. It would be good to know how much money they spend on them, and I am sure they could find better ways to spend it. (FP5)

It feels like something they put in a long, long time ago. It's archaic and it's just never changed. It's like well, we haven't had any attacks for such a long time, so who wants to be the first one to move it? (FP2)

There was also discussion about the prospect of deciding to remove the nets.

FP10: It's going to be a big PR nightmare to get rid of them, though. They'd be up in arms.

I: Who would be up in arms, do you think?

FP11: You can say we are going to remove that, but it has been proven away. I agree, I think you're better to just take it out than face an uproar.

FP1: But why don't they say that they're going to patrol more, you know? Put people out and keep an eye on them. That makes more sense, and do a big, you know, education campaign and just educate people about sharks, because sharks aren't actually attracted to us. They don't want us, you know, the only time they come to the beach is when they are injured.

FP3: But it's what (FP2) said, if you take them away and place them with something else, the first time someone gets bitten, they will say that's because you took the shark nets away. It's almost like they're getting locked in. Just take them away and don't tell anybody.

FP2: They don't tell anyone anything anyway! When's the last time you saw a commercial about the shark nets in New South Wales? Come on down to New South Wales, we've got the only shark nets.

FP11: But people get bitten on the beaches with the nets anyway.

Participants acknowledged the 'government' positively for seeking alternatives to nets. They said they felt that nets have been made obsolete by newer approaches and technologies that were more targeted at dangerous sharks, and less 'invasive'.

It is good to see that alternatives have been sought and the government is actually looking at different ways of shark management and is making progress. (FP8)

I was stoked because I think that they are investigating if they can get rid of the nets, and investigating if it's become more dangerous because we have seen more statistics of shark attacks in New South Wales. (FP6)

There was also considerable cynicism about 'government' motivations that drive the use of different shark harm mitigation strategies. People questioned government's priorities and ability to choose the 'best' path ahead because of fear of an angry community response.

I feel like it's mainly to do with management of people's expectations of what the government should do, rather than actually looking at what is effective. Because most of what could be more effective I think, and more cost-effective, is probably seen and would be reported by media as a much softer approach, which means that the fall out if something did happen would be too much for the government to risk, I feel. (FP3)

... everything that we've discussed today is about saving the government's face if somebody gets bitten. You know, they can say we've got shark lines out there, we've got drumlines, we've got nets. You know, it's not our fault that one slips through, but rather they should be educating the population about what is there and how they can protect themselves and what actually the true statistics are. (FP2)

I think that the DPI and the government have kneejerk reactions when someone gets hurt, and for some reason they think that one person's life is worth 20,000 sharks' lives, and it just doesn't make sense to me. There are better ways we can do it. (FP4)

The group mainly believed that public relations drove both in-water measures, providing false security to the uninformed. Participants said they would be happy if the government moved away from mesh nets.

And with beach management, it's a media exercise, like we've discussed. (FP7)

Um, as a kid, my mum used to tell me that's what we tell tourists to make them feel safer. So, it's, I guess ... to make people who don't know much about it feel safer, yeah. (FP9)

The group argued governments leveraged confusion around the specifics of the nets.

I think the government is really happy that everyone is confused. They all think it does something. All the tourists are really happy that there's a net out there. They don't have to say it. (FP2)

5.6.2 Aerial surveillance (drones and helicopters)

5.6.2.1 Table 15: Freshwater aerial surveillance findings

	Advantages	Disadvantages
Drones	<ul style="list-style-type: none"> • Non-invasive • Multipurpose • Better value aerial surveillance • Will get better and better 	<ul style="list-style-type: none"> • Rely on good water and wind conditions • Presence and alerts can scare people unnecessarily
Helicopter	<ul style="list-style-type: none"> • Non-invasive • Aerial view 	<ul style="list-style-type: none"> • Expensive • Too infrequent to effectively reduce risk

Participant preferences, reasoning and other comments

Participants were all aware of both aerial surveillance approaches, but not fully aware of the programs related to their beaches. They preferred drones rather than helicopters.

Yes, if we're comparing it, then I think the drone option is better. (FP6)

The group championed several features of drones when compared with helicopters, including lesser impact on the marine life and the environment, lower costs and versatility to provide a range of safety services and support.

Now they are using drones for a lot more other operations in terms of lifesaving and different things. (FP7)

Although their utility was limited by prevailing conditions, drones were perceived to be in the early stages of development, some way from reaching their full potential in terms of performance and function.

They are a good advantage because it gives us more sight on the beaches and whatnot, but it's quite hard to spot sharks if it's like murky water. (FP10)

But in terms of just safety for ocean users and for beach users, I think they could be, you know, down the track very effective. (FP6)

It sounds like something that would be really successful in five years when the drones are better, they can handle the winds and they can have cameras on them and they are more powerful than they are now. Plus, your iPhone cameras have been building up. That would be great. (FP7)

Helicopters had some supporters who claimed that their noise can be used to drive sharks out to sea, and do emergency rescues. However, the same people said they felt the infrequency of helicopter fly-bys greatly offset this advantage, and used a cost argument to encourage more drones to be bought.

If they do spot a shark, they can hover over it and then I have seen them push it out to sea and scare them out to sea, and move them away from the beach. You can't do that with the drone and you can't do that with anything else. If there is a situation though where they do fly up and fly back and if there is something there 20 minutes ago, they are that far away, so they are not immediately there. If we are talking about rescues, nothing else that we have spoken about can effect a rescue out to sea. (FP8)

[Helicopters] can only be in one spot, and they are flying up and down the coast. It's like well, great, we saw a shark two hours ago here, whereas the drones you can have them on every beach, all operating at the same time. So, I think they should be installed everywhere. (FP9)

Yeah, I think get rid of them. They're super expensive, they're super loud which I think I'm pretty confident would have an impact on marine life as well as the surfers. But they can't be any more useful than a drone, and the drone doesn't require the same amount of labour and a stupid amount of cost of the actual asset. If they got rid of the nets and the helicopters, they'd have a big budget to buy a shitload of drones. (FP5)

The risk of running 'soft approaches' was raised and some participants believed it may be a barrier to over-reliance on drone surveillance.

Drones and shark spotting would be seen as a soft approach because it is quite passive. I think if something did happen on a drone patrolled beach which didn't have nets, then the fallout for the government which is what I imagine they fear, would be ... and from the media, would be pretty crucifying, yeah. (FP3)

5.6.3 Technology and monitoring

5.6.3.1 Table 16: Freshwater technology and monitoring findings

	Advantages	Disadvantages
VR4G	<ul style="list-style-type: none"> • Good for research to tell us about sharks 	<ul style="list-style-type: none"> • Only detecting tagged sharks is very limiting • The means of tagging is distressing for sharks • Confusion about purpose
SharkSmart App	<ul style="list-style-type: none"> • Only good if we tag more sharks • Good to know where there are more sharks 	<ul style="list-style-type: none"> • Not good for people in water • Too many push notifications can scare or just be irritating • Not enough sharks tagged
Personal deterrents	<ul style="list-style-type: none"> • People taking responsibility 	<ul style="list-style-type: none"> • Uncertainty about effectiveness • Cumbersome

Participant preferences, reasoning and other comments

There was generally low awareness of the VR4G. There was greater knowledge of the app but the SharkSmart App was somewhat confused with Dorsal, the free community-based shark alert app.

Drones and shark spotting would be seen as a soft approach because it is quite passive. I think if something did happen on a drone patrolled beach which didn't have nets, then the fallout for the government which is what I imagine they fear, would be ... and from the media, would be pretty crucifying, yeah. (FP3)

It's being compromised by people [surfers] who want to protect their spots, they put it on Dorsal. (FP10)

Oh, so that is the Dorsal app. This is a different one (I2)

For most, there was low awareness of personal deterrents, but some had very extensive understanding and experience, especially with SharkShield, which was best known across the group.

Participants encouraged the notion of personal responsibility in the ocean. For most, this meant that the ocean was a wilderness, that people should acknowledge the ocean was the shark's home and sharks must be respected.

I think it's good because I think most people in this room would agree that anyone that goes in the ocean is at their own risk and they know that it is an environment that is basically risky. It is one of the few places you can go that isn't covered in red tape. (FP5)

Some people valued the VR4G as an important piece of technology for the future of understanding sharks, but several questioned their purpose, the utility of data collected, and value for money.

I think the only value is data collection, just really truly understanding what is going on, because to your point, don't let your kids go swimming up there at Port Stephens. (FP7)

I guess are they expensive? Is there any point to them, if they were going to collect a small amount of data? Is it worthwhile? Is it giving a good enough sample? How do you know how many are bypassing it, and then what? Is it actually giving you data that you can use? Are they expensive? If not, maybe it's no harm having them just floating around out there, if they're not harming anything. But what's the point? (FP9)

The VR4G was perceived to have some significant limitations as a strategy for reducing harm from sharks. The main shortcoming stated was it can only detect and issues warnings about tagged sharks, but another feature troubling the group was the shark's perceived suffering in the tagging process.

Well, as everyone else has already said, you might have ten sharks go past the thing but none of them are tagged. You have a shark attack when the thing is 500 metres off there, well, why didn't it pick it up? Because the shark wasn't tagged before, it wasn't caught, so we should tag more sharks. If you want to use it in that respect, you've got to tag more sharks. So, as people were saying, you may not like the way that they are being caught and tagged, but if you are going to use these things, they can't pick up on the retina of a shark. It doesn't work that way, right? So, they've got to be tagged, and if you are not going to catch them and tag them, then those things are useless. They are just junk sitting in the ocean. (FP6)

If they're going to do it, they have to find a better way to tag, because that tagging is just not, it's just not acceptable. It seems like a lazy way of doing it. (FP1)

The SharkSmart App was valued for giving information that helps people to make more informed ocean use decisions, especially lifeguards. It was also criticised for giving too many irrelevant or irritating alerts, and likely ineffectiveness due to the low number of sharks tagged. Some said they would prefer more resources go to lifeguards and drone surveillance than on tagging/monitoring sharks.

I mean, you have spelt out that if a large shark that has been tagged comes near a listening device near Manly, well, Manly is going to get the alert. So, it is up to us to make the call, if you've got the app, you might not go swimming that day, you might not go training, or whatever. The advantages are obvious. The disadvantages are going to be how the sharks get tagged in the first place, and we are all going to have issues with that. (FP6)

You don't know if it's different sharks. The one thing I would say, when we talk about should we tag more sharks to make it more effective, we are never going to be able to tag all the sharks. (FP4)

You can't, you're not going to be on your surfboard with your app with you. So, it gets ... I know it goes to the lifeguards as well, um, but yeah, I just think too, I think it's like pretty low the amount of people that die worldwide from sharks every year. I think it's something like five or 10 people. It just seems like an awful lot of trouble and money to spend to sort of save, you know, potentially five people. I think they, you know, should be putting their money into lifeguards who are saving people from drowning nearly every day. (FP11)

Personal deterrents triggered a wide-ranging discussion. Some of the discussion was very speculative, based on uncertainty and questions about the effectiveness and design of personal deterrents. Some reported that deterrents were traditionally very cumbersome, but evolving in their user-friendliness and effectiveness.

You touch them you get shocked. They're cumbersome. (FP6)

Beyond the advantages and disadvantages, participants questioned the ethics of using them, some having heard that by deterring sharks from oneself they potentially raise the risk of harm to other surfers. They also questioned the harm a deterrent shock causes sharks, and the ethics of selling some shark deterrents that have very minimal or no deterrent effect.

Some believed deterrents such as Shark Shield attracted sharks (based on personal experience using them for 15 hours in open ocean swims), and then potentially harmed sharks when they got too close.

Yeah, it's just sort of here and you swim a little bit off. So, you're kind of within the zone. You don't know how big the zone is, but um, I agreed and I always thought that it does attract the shark in the first instance, and it looked like it attracted the shark to me. But this thing just stayed underneath me, 14 foot, maybe 10-foot underneath me, for five hours. (FP12)

Participants questioned the effects such technologies had on sharks. Most conceded, however, that if perfected such devices would be a good option for those using unpatrolled beaches.

I am absolutely convinced that that shark flinched from the effects of the shark shield. Whether or not it attracts them, it is still a big debate. (FP12)

5.7 Discussion of findings across the trials

This section brings together the findings from the different trial sites to more clearly present patterns and allows comparison. Awareness levels across all the groups were very similar, with all participants aware to some extent of in-water and aerial surveillance approaches. The researchers observed small differences in awareness, mostly for personal deterrents, but differences were individual rather than regional.

On several occasions, in the discussion groups' participants reported they had attended community information sessions. The interviewers perceived these people tended to have remembered much of what they had been told, that they were more supportive of the DPI programs, and accepting of their reasoning and goals. In short, these information sessions seemed to have had the intended communication effects, at least for those directly exposed to them.

5.7.1 Advantages highlighted at the different trial sites

Table 17 enables a comparison of the advantages recorded across all sites. The table shows that SMART drumlines were somewhat valued at all locations for their tagging and potential to contribute to the understanding of sharks through research. As a shark management strategy, they were also appreciated at three sites for reducing harm levels to sharks, and for being more humane than shark nets. Apart from Avalon, they were not valued as a strategy for reducing the risk of harm from sharks.

Most groups believed mesh nets offered some reassurance ('to make people feel safer') to people who were ill or under-informed about shark management. All groups overwhelmingly felt that those reassured were misguided.

Drones were the most widely popular strategy. Participants valued them for several advantages including cost, non-invasiveness, and versatility for general surveillance and ocean rescue functions.

Helicopters were considered advantageous for their speed, non-invasiveness and ability to cover wide areas of the coast, including unpatrolled beaches.

Some participants valued the VR4G for contributing to research and understanding of shark movements.

The SharkSmart App was considered useful to warn of potential shark activity and most useful for those responsible for beaches or groups of people (eg tourist operators).

Personal deterrents were advantageous as the only protection available to people using unpatrolled coastlines and for those seeking to take greater personal responsibility.

5.7.1.1 Table 17: Advantages highlighted at the different trial sites

Advantages	Tathra	Pambula	Newcastle	Avalon	Freshwater
SMART drumlines	<ul style="list-style-type: none"> • Research through data gathering • More humane than nets (sharks not generally harmed) 	<ul style="list-style-type: none"> • Good for research • Good for shark population 	<ul style="list-style-type: none"> • Shark lives • Tagging helps research and understanding 	<ul style="list-style-type: none"> • Reduce bycatch • Sharks survive • Perception of government making waters safer • Part of comprehensive mitigation program 	<ul style="list-style-type: none"> • Research function is advantageous
Mesh nets	<ul style="list-style-type: none"> • Make people feel safe (good for tourism but not based on results) 	<ul style="list-style-type: none"> • The unaware feel safer 	<ul style="list-style-type: none"> • Stats show they are proven to limit shark attack • Add to safety of humans 	<ul style="list-style-type: none"> • Work to make people feel safer 	<ul style="list-style-type: none"> • Reassuring for tourism and business • Prevent large sharks from taking residence • Long-term association with low harm rates
Drones	<ul style="list-style-type: none"> • Good for rescues and general water safety surveillance • Minimising risks to lifeguards • Lower cost surveillance – can spend more time surveying • Multipurpose water safety tool 	<ul style="list-style-type: none"> • Valuable multipurpose tool • Noninvasive • Can be automated 	<ul style="list-style-type: none"> • Valuable tool for surf rescue and shark surveillance • Cost-effective • Improving 	<ul style="list-style-type: none"> • Non-lethal risk reduction • A multipurpose non-invasive tool • Good for alerts and for watching sharks move away from the beach • Tech will make them the best tool in future 	<ul style="list-style-type: none"> • Non-invasive • Multipurpose • Better value aerial surveillance • Will improve
Helicopters	<ul style="list-style-type: none"> • Large coverage area • Hopefully assist with rescue • Can hover and drive sharks out to sea 	<ul style="list-style-type: none"> • Superior image of sharks 	<ul style="list-style-type: none"> • Cover large areas • Cover unpatrolled beaches 	<ul style="list-style-type: none"> • Instant alerts • Non-lethal • Reassuring for some 	<ul style="list-style-type: none"> • Non-invasive • Aerial view
VR4G	<ul style="list-style-type: none"> • Tracks tagged sharks (some better than nothing) 	<ul style="list-style-type: none"> • Yellow is good colour (stands out more than red) 	<ul style="list-style-type: none"> • Good for research and understanding sharks • Visibility can be reassuring 	<ul style="list-style-type: none"> • Good for research • Non-lethal • Maybe reassuring for some swimmers 	<ul style="list-style-type: none"> • Good for research to tell us about sharks
SharkSmart App	<ul style="list-style-type: none"> • Awareness of sharks gives some personal control of risk • Good for tourism and event operators with water-based clientele 	<ul style="list-style-type: none"> • Can see where sharks are 	<ul style="list-style-type: none"> • App helps people take responsibility 	<ul style="list-style-type: none"> • Meets the needs of the fearful (many alerts) 	<ul style="list-style-type: none"> • Only good if we tag more sharks • Good to know where there are more sharks
Personal deterrents	<ul style="list-style-type: none"> • They reflect that it is about personal responsibility • They give people a sense of security • Good placebo 	<ul style="list-style-type: none"> • Puts it back on individual 	<ul style="list-style-type: none"> • No positives offered 	<ul style="list-style-type: none"> • Can be reassuring • Can help in remote places away from help 	<ul style="list-style-type: none"> • People taking responsibility

5.7.2 Disadvantages highlighted at the different trial sites

Table 18 allows disadvantages recorded across all sites to be compared. The table shows similarities across all participant groups for in-water mitigation. There were two dominant themes across the trial sites concerning SMART drumlines. They were cost and labour intensive to implement, and participants saw trial results as evidence of their ineffectiveness in catching target species. Some groups reached a consensus there must be alternatives to tagging to reduce the risk of harm to sharks. Perceived harm was based on contractor skill and the time it takes to reach the shark (the 30-minute maximum target was often questioned). In short, participants perceived drumlines as research tools not harm mitigation tools.

All groups did not think well of mesh nets. All emphasised cruelty and indiscriminate killing. Many groups said nets harmed the environment, were expensive to maintain and ineffective with target sharks. There was a very strong and widespread belief shark nets were 'old technology'.

The only disadvantages of drones repeatedly mentioned were their limitations with suboptimal water and weather conditions. Helicopters were also considered to have limited use in adverse water and weather conditions, but the main, repeated disadvantages were their high cost and infrequent surveillance at any one location.

The VR4G was considered an effective technology but ineffective for reducing harm from sharks because only a tiny proportion of sharks were tagged.

Groups criticised the SharkSmart App for sending out too many irrelevant alerts that became an irritation. Also, because it was not available to most people at risk who were in the water.

Personal deterrents were seen as expensive and cumbersome and participants did not trust them. They were considered to potentially lead to water users ignoring danger signs and making poor decisions.

5.7.2.1 Table 18: Disadvantages highlighted at the different trial sites

Disadvantages	Tathra	Pambula	Newcastle	Avalon	Freshwater
SMART drumlines	<ul style="list-style-type: none"> • There is low risk in the area, SDs make sharks more salient than they should be • SDs demonise sharks (they want to attack us) • High cost for low research gain (tiny number tagged) 	<ul style="list-style-type: none"> • Indiscriminate with non-targets • Cruel for catch • Visible buoys increase fear 	<ul style="list-style-type: none"> • Very fallible system • Too costly • Ineffective, need too many to make a difference 	<ul style="list-style-type: none"> • Sharks distressed • False security • Ineffective mitigation • Expensive 	<ul style="list-style-type: none"> • Sharks are distressed unnecessarily • Ineffective as mitigation • Only purpose is for research, there must be a better way • Value of data questioned • Cruel way to get tag and get data
Mesh nets	<ul style="list-style-type: none"> • Antiquated approach • Cruel • Waste of resources 	<ul style="list-style-type: none"> • False sense of security • Too much bycatch 	<ul style="list-style-type: none"> • Too much bycatch • Too labour intensive • Ineffective 	<ul style="list-style-type: none"> • Ineffective at catching target sharks • Kill sharks and non-target species 	<ul style="list-style-type: none"> • Too much bycatch • Ineffective, they don't enclose • Any reassurance is

		<ul style="list-style-type: none"> Waste of money, high maintenance 		<ul style="list-style-type: none"> False security – people don't understand Outdated, obsolete Expensive 	<ul style="list-style-type: none"> false security - PR exercise only Very expensive
Drones	<ul style="list-style-type: none"> Condition dependent Privacy concerns Noise and visual pollution Small coast range 	<ul style="list-style-type: none"> Can create too many alerts and fear Not durable, expensive to replace Noise pollution Condition-specific 	<ul style="list-style-type: none"> Limited use in poor conditions Requires high-level training 	<ul style="list-style-type: none"> Need ideal weather and water conditions Need good software Require well-trained humans; prone to human failings 	<ul style="list-style-type: none"> Rely on good water and wind conditions Presence and alerts can scare people unnecessarily
Helicopters	<ul style="list-style-type: none"> High cost for low return Condition dependent Need land personnel support 	<ul style="list-style-type: none"> High cost Ineffective Sight and sound pollution Condition-specific 	<ul style="list-style-type: none"> Expensive Don't help surfers Infrequent cover 	<ul style="list-style-type: none"> Ineffective because of infrequent timing of patrol Expensive Miss a lot of sharks Noisy 	<ul style="list-style-type: none"> Expensive Too infrequent to effectively reduce risk
VR4G	<ul style="list-style-type: none"> Only tracks tagged sharks (not enough to make much difference for beach safety) Visual reminder of shark presence in area 	<ul style="list-style-type: none"> Need good land back up Only tracks tagged sharks 	<ul style="list-style-type: none"> Not directional Small area covered Relies on good systems for alerts to be effective 	<ul style="list-style-type: none"> Not effective mitigation, too many not tagged Not directional, not enough information No enough of them, leaving gaps along the coastline 	<ul style="list-style-type: none"> Only detecting tagged sharks is very limiting The means of tagging is distressing for sharks Confusion about purpose
SharkSmart App	<ul style="list-style-type: none"> App is annoying it goes off so often App deters people from water/change behaviour They alert but do not suggest action 	<ul style="list-style-type: none"> Not helpful out in water Too many alerts scare people 	<ul style="list-style-type: none"> App requires authorities to trust and use for alerts to be useful No good for surfers in water 	<ul style="list-style-type: none"> Too many alerts of low relevance Not reducing risk False reassurance or misinform level of risk 	<ul style="list-style-type: none"> Not good for people in water Too many push notifications can scare or just be irritating
Personal deterrents	<ul style="list-style-type: none"> Better ones cost too much Low risk, high-cost ratio Effectiveness not known 	<ul style="list-style-type: none"> Too expensive Uncertainty about effectiveness Unintended shock risk to humans and marine life 	<ul style="list-style-type: none"> Waste of money Not trusted 	<ul style="list-style-type: none"> False security Expensive Bad if they make you make poor decisions 	<ul style="list-style-type: none"> Uncertainty about effectiveness Cumbersome

5.7.3 Preferences highlighted at the different trial sites

Table 19 enables comparison of preferences recorded across all the sites. Letters in the box indicate what an identifiable majority of the group preferred this strategy to be used for. Some strategies, such as mesh nets and helicopters, received little support, and the group did not see them as a viable and desirable option.

5.7.3.1 Table 19: Preferences highlighted at the different trial sites

Preference	Tathra	Pambula	Newcastle	Avalon	Freshwater
SMART drumlines	R	R	R		R
Mesh nets					
Drones	BM, SM,	BM, SM	BM, SM	BM, SM	BM, SM
Helicopters					
VR4G	R	R	R	R	R
App	PR	PR	PR		BM, PR
Personal deterrents	PR	PR	(No subsidies)	PR (Yes subsidies)	PR
Education	PR	PR		PR	

^{BM} Beach management for public safety

^{PR} Promotes personal responsibility

^R Research

SM Shark mitigation

6

CONCLUSIONS AND RECOMMENDATIONS

The study at the five trial sites identified common and salient attitudes that should be considered when planning and communicating shark management policy.

6.1 SHARK MANAGEMENT PRINCIPLES

The study suggested prevailing principles driving preferences in shark management:

- People preferred 'non-invasive' mitigation approaches that do not harm sharks or other marine life;
- Mitigation strategies should be proportional to, and tailored to, local needs;
- People were generally encouraging of newer technologies designed to reduce risk of harm from sharks, with increasing interest in approaches that more narrowly targeted potentially dangerous sharks;
- People preferred shark management strategies that were cost-efficient, reduced risk of harm from potentially dangerous sharks, and were integrated with local beach management;
- People perceived multiple uses (eg drones for general beach safety) very positively;
- Detection and alerts were important aids to beach management, but without more tagged sharks there was considerable scepticism about the effectiveness of the VR4G and the SharkSmart App;
- Automated alerts were most valued where they could be assessed with contextual information, otherwise shark 'ping' alerts could cause panic, fear and unnecessary beach evacuations;
- Integration of services, personnel and communication were important and should be systematised and standardised to improve understanding of expectations of all involved; and
- Some participants said they thought 'making tourists feel safer to keep visiting' was sufficient justification for mitigation.

Most participants were enthusiastic supporters of some form of risk mitigation in their locale. However, some said they felt shark harm mitigation strategies were not justified by the low statistical risk of harm from sharks along their stretch of coast. There was a feeling among some that the high visibility of many strategies (drones, SMART drumlines, helicopters, VR4G) created a disproportionately high awareness, leading to unjustified fear, and associated problems.

6.2 ATTITUDES TO SHARK MANAGEMENT STRATEGIES

This study reports some important dimensions in thinking associated with current shark management strategies:

- The feasibility of SMART drumlines as mitigation was questioned because of the small catch of target sharks in all test sites
- SMART drumlines represented a temporary advance in shark management from shark nets because SMART drumlines were perceived to do less harm to sharks and other marine life, but did not meet community expectations and hopes for effective, efficient, non-invasive approaches to reducing risk of harm from sharks, including:
 - The shark's negative experience of the process of the catch, tag and release (most people don't want sharks to suffer);
 - Whether removing sharks taken on baited hooks was valuable risk mitigation, when many more sharks remained in the sea;
- The perceived scale of risk of harm from sharks in the locale (Is there a need for mitigation? If not, mitigation may be considered wasteful, or mitigation could create fear of sharks where previously no problem was perceived);
- The contributions to research (mostly associated with tagging sharks) and improved understanding of movements of sharks and seasonality in shark behaviour;
- Whether or not SMART drumlines added to risk to humans by attracting sharks to beaches used for swimming and surfing;
- Mesh nets were considered to be old technology without a future role in mitigating the risk of harm from sharks;
- Mesh nets failed to meet community expectations in multiple ways:
 - They were known to cause suffering and death to a wide range of marine life;
 - They were believed to be inefficient in terms of operating cost and ineffective in terms of protection;
- Mesh nets were perceived to offer some reassurance to visitors/tourists that regular ocean users regarded as a false sense of security, and some suggested there would be an economic cost if nets were permanently removed;
- Drones were perceived to be the future of not just shark management but beach and ocean safety generally, for several reasons:
 - Low-cost of drones and operation;
 - Versatility of drones as multipurpose surveillance and rescue tool;
 - Improvements in AI shark identification and other technologies;
 - The speediness of reaching potential victims of encounters; and
 - Their non-invasive nature;
- Helicopters were seen as useful but did not pass the return-on-investment test. Their high cost did not justify their use, and their beach pass overs were deemed to be too infrequent for effect shark management;

- VR4G listening stations were predominately seen as a research tool with very little regard for shark management while so few sharks were tagged;
- People associated with beach tourist especially valued the SharkSmart App. They believed it gave 'some' control over sites or times to avoid using the water, but generally acknowledged the low number of sharks tagged severely limited the effectiveness in preventing interactions with sharks;
- The SharkSmart app was frequently confused with Dorsal;
- Some participants also indicated over-frequent alerts resulted in them abandoning the SharkSmart App because they found the alerts irritating and/or fear-inducing. Some said the app continually reminded them of sharks when previously they hadn't been a concern;
- Some people saw personal deterrents as hoaxes preying on people's fears, potentially increasing harm to people because of the false sense of security that marketing claims gave;
- Personal deterrents were also seen as highly useful for those worried about entering the ocean, and might be the only protection available in remote areas. This group felt that more resources should go into improving them; and
- Personal deterrents were considered prohibitively expensive for surfers.

6.3 RECOMMENDATIONS

The recommendations for shark management that arose from the project are:

1. Explore the feasibility (including social and economic costs and benefits) of removing nets and favouring community-preferred non-invasive shark management;
2. Address the perception that SMART drumlines attracted sharks, or people may reject locating SMART drumlines anywhere near people;
3. Address the perception that SMART drumlines were effective only for research, and do not contribute to mitigating harm from potentially dangerous sharks;
4. Clarify the roles of the different elements of the strategy ie distinguish elements intended for research and those intended for direct mitigation of interactions with potentially dangerous sharks;
5. Explore the feasibility of the SharkSmart App and continually improve the functionality to allow people to specify types/range of alerts received;
6. Continue to be transparent and provide evidence of the efficacy of interventions (eg SMART drumlines catch and shark outcomes after release);
7. Address uncertainty about outcomes for sharks caught by SMART drumlines; rebut or justify claims of suffering before, during and after tagging;
8. Continue investing in R&D for technologies that mitigate risk to humans, sharks and other marine life; and
9. Focus on functionality and affordability that meets surfers' needs in further developing personal deterrent approaches.

Appendix 2. Community drop-in stands



Appendix 3. Discussion guide

‘Assessment of the attitudes of beach and ocean end-users to shark mitigation since trials of SMART drumlines’

Research question

What are the attitudes of beach and ocean users to shark mitigation since trials of SMART drumlines?

Sub-questions

- i. What are attitudes to, awareness of, and perceived advantages/disadvantages of in-water shark management approaches - SMART drumlines, traditional drumlines and mesh nets?
- ii. What are attitudes to, awareness of, and perceived advantages/disadvantages of aerial shark surveillance - helicopters and drones?
- iii. What are attitudes to, awareness of, and perceived advantages/disadvantages of technology and monitoring - VR4G listening stations and associated tagging, the SharkSmart App, and personal deterrents?

Venues:

Bega Valley region

Tathra (Tathra)

Merimbula/Pambula (Pambula)

Newcastle

Sydney Northern Beaches (Barrenjoey to Newport [Avalon]; Dee Why to Manly [Freshwater]);

Mitigation methods to be discussed

1. In-water management
 - a. SMART drumlines - all three regions
 - b. Mesh nets - at Sydney and Newcastle beaches
2. Aerial surveillance
 - a. Helicopter shark surveillance - all three regions
 - b. Drone shark surveillance – all three regions (as shark detection tool and as potential for standard Surf Life Saving NSW and other beach authority safety equipment)
3. Technology and monitoring
 - a. VR4G listening stations - all three regions
 - b. SharkSmart App - all three regions
 - c. Personal deterrents – all three regions.

FG Questions	Prompts
<p>Before the start – everyone completes a participant profile sheet. RECORDING</p>	
<p><u>Moderator Opening - Min 0 5.30</u></p> <p>Welcome and thank you for giving your time for this study.</p> <p>My name is Peter Simmons and this is Michael Mehmet. We work with ILWS research centre at CSU. [We are running this study with support from the NSW Department of Primary Industries].</p>	
<p><u>Introduction – min 1</u></p> <p>Take a minute to introduce the session - then start talking</p> <p>Today we will be talking about some approaches to managing sharks, including in-water approaches, aerial surveillance and detection technologies.</p> <p>The results will be used in a report and papers we will give to the Department of Primary Industries to help inform their policy and communication around sharks and shark management.</p> <p>You were chosen because you have an interest in or experience of the NSW coast.</p> <p>A few principles to guide our discussion:</p> <ul style="list-style-type: none"> • This a round table where all views are important and it's important to hear from everyone; • There are no right or wrong answers, just differing points of view; • We're taping the session so we need one person speaking at a time; • You don't need to agree with others, but you need to listen respectfully as others share their views; • People have agreed to come here today on understanding of confidentiality so I urge you not to repeat what is said; • Not seeking expert opinion but ordinary opinion; • Mobile phones off please; and • Lot to get through - let's get started. <p>My role as moderator will be to guide the discussion. Keep it flowing. Away by 7pm.</p>	
<p><u>Ice-breaking – introductions – min 3 5.33</u></p> <p>Start with introductions – I'll go around the room ... [in less than a minute] can you introduce yourself (by name for our transcriber Glenda) and tell us about the ways that you use the beach or ocean?</p>	
<p>Exploring – general attitudes to shark mitigation - open-ended questions about going in the water – min 13</p>	
<p>I can hear that many of you go in the water. I'll go around the room: when I say the word 'sharks', what comes to mind?</p>	
<p>Focus question – SMS 3 main approaches – min 23 5.53</p>	
<p>In recent years, the NSW Government has introduced a 'shark management strategy'. It has three main approaches to preventing harm:</p> <p>First, in-water shark management;</p> <p>Second, aerial shark surveillance; and</p> <p>Third, technology and monitoring.</p>	
<p>We will start with some questions about in-water shark management.</p>	<p>Awareness? What have you heard?</p>

<p>There are two main methods of in-water shark management we will discuss: (i) SMART drumlines and (ii) mesh nets.</p> <p>Have you heard of SMART drumlines before today?</p>	
<p>SMART drumlines (Shark Management Alert in Real Time)</p> <p>In this area, you have recently had a trial of SMART Drumlines let me tell you how these operate.</p>	
<p><u>Moderator explains and shows 2 DPI diagrams –</u> <u>Diagram 1 shows SMART Drumline illustration</u> <u>Diagram 2 shows local map of locations</u></p> <ul style="list-style-type: none"> • Traditional drumlines capture and kill sharks. SMART drumlines capture sharks with a baited hook that triggers a satellite GPS alert and a boat crew arrives within 30 minutes to tag and relocate the shark alive 1 km out to sea. Because they have bait, they need to be brought in each day. • They are only used when a team is on hand to respond. <p>SMART drumlines is the way most sharks are tagged.</p>	
<p>Let's go around the room. What are the advantages and disadvantages of SMART drumlines?</p>	<p>Effectiveness – do they mitigate human encounters?</p> <p>Bycatch – do they cause harm to other species?</p> <p>Lethality – do they harm sharks?</p> <p>Cost – fixed and marginal</p> <p>Reassurance – do they reassure or do they feed fear of sharks?</p>
<p>Mesh Nets</p> <p>Now we'll talk about mesh nets. Have you heard of mesh nets? Before today?</p>	<p>Awareness? What have you heard?</p>
<p><u>Moderator explains.</u></p> <p>Mesh nets</p> <ol style="list-style-type: none"> 1. Shark nets are installed near a beach, according to prevailing conditions, generally parallel to the beach near surf clubs and patrolled swimming areas. 2. The shark meshing program was introduced in 1937 and there are now 51 netted beaches between Newcastle and Wollongong. 3. Shark nets do not create an enclosed area or provide a barrier between beachgoers and sharks. They are designed to reduce the likelihood of shark interactions by catching large, potentially dangerous sharks aggregating near the netted beach. <p>Shark nets currently used in NSW are 150 metres long by six metres deep, with a mesh size of 60 cm, set below the surface in about 10 to 12 metres of water, within 500 metres of the shore.</p>	
<p>I'm going to show you graphs comparing the catch data for SMART drumlines and nets for this area during the SMART drumlines trial period. Then I'll ask for your views on these shark mitigation methods, and what you feel are the advantages and disadvantages of each method.</p>	
<p>SHOW GRAPHS comparing catch data for SMART drumlines and nets during the trial period, i.e. 01 Feb to 30 Apr 2019.</p>	

<p>What are the advantages and disadvantages of mesh nets?</p>	<p>Effectiveness – do they mitigate human encounters?</p> <p>Effectiveness</p> <p>Bycatch</p> <p>Lethality</p> <p>Cost</p>
<p>Now for some questions about aerial surveillance as shark management. Minute 45 6.15</p>	
<p>Have you heard of drone surveillance before today?</p>	<p>Awareness? What have you heard? Lethal – non-lethal</p> <p>Reassurance</p> <p>Effectiveness</p> <p>Costs</p>
<p><u>Moderator explains.</u></p> <ul style="list-style-type: none"> • Drones – are unmanned aerial vehicles and have been trialled by the DPI at 19 beaches as a shark detection tool, and to assess the extent to which they could potentially become part of the standard beach safety equipment used by SLSNSW and other beach authorities. • They are piloted by lifeguards/lifesavers, flown several times a day and provide real-time vision of coastal waters. • If a dangerous shark is spotted, a siren sounds to alert swimmers and surfers. 	
<p>What are the advantages and disadvantages of drones?</p>	<p>Having heard about SDs – how would you compare them with drones?</p> <p>As shark detection tool and as potential for standard Surf Life Saving NSW and other beach authority safety equipment.</p> <p>Effectiveness</p> <p>Bycatch</p> <p>Lethality</p> <p>Cost</p>
<p>Have you heard of helicopter surveillance before today?</p>	<p>Awareness? What have you heard?</p>
<p><u>Moderator explains.</u></p> <ul style="list-style-type: none"> • Helicopters have been trialled in seven regions between Eden on the Far South Coast to Tweed Heads in the state’s north over school holiday periods. • Contracted helicopters with trained observers onboard search the water for sharks within 500 metres of a beach. • There are daily flights and if a potentially dangerous shark is spotted, the helicopter reduces height to hover and sounds a siren to alert swimmers and surfers, and beach authorities are notified. 	

<p>What are the advantages and disadvantages of Helicopters?</p>	<p>Having heard about SDs – how would you compare them with helicopters?</p> <p>Effectiveness</p> <p>Bycatch</p> <p>Lethality</p> <p>Cost</p>
<p>Now for some questions about technology and monitoring as shark management. Minute 62. 6.32</p>	
<p>Have you heard of VR4G listening stations before today?</p> <p>Or the SharkSmart App?</p>	<p>Awareness? What have you heard?</p>
<p><u>Moderator explains. VR4G and Shark Smart- (Michael hands out VR4G diagram – Yellow buoy)</u></p> <ol style="list-style-type: none"> 1. The (VR4G) listening station detects tagged sharks and other marine animals within 500m. Captured information goes immediately to a satellite and is then sent to the public and beach authorities via Twitter @NSWSharkSmart and the Shark smart App. DPI has trialled 21 listening stations along the coast. 2. SharkSmart App. NSW DPI owns the SharkSmart App. It receives information about shark movements from the network of listening stations, as well as detections from drones, helicopters and sharks caught on SMART drumlines. It makes the information freely available to the general public. People with the app on their devices, especially phones, can receive instant alerts about sharks. This way the public can monitor shark activity. <p>So, the VR4G detects tagged sharks within 500 metres and communicates that to the SharkSmart App and Twitter to followers.</p>	
<p>First - What are the advantages and disadvantages of the VR4G?</p> <p>Second - What are the advantages and disadvantages of the SharkSmart App?</p>	<p>Having heard about SDs – how would you compare them with VR4G and SharkSmart App?</p> <p>Effectiveness</p> <p>Bycatch</p> <p>Lethality</p> <p>Cost</p>
<p>Do you believe people should take responsibility for their personal safety when entering the ocean?</p> <p>With that in mind, have you heard of personal shark deterrents before today?</p>	<p>Awareness? What have you heard?</p>
<p><u>Moderator explains.</u></p> <ol style="list-style-type: none"> 1. Designed to protect the individual using the deterrent rather than a group of people at a given location – include: electric, magnetic, chemical and visual deterrents (Table 1). 2. Developed to reduce the risk of an interaction with a shark, and are primarily aimed at surfers/bodyboarders who often surf at less crowded locations at dawn and dusk. 3. The use of deterrents is a personal choice and individuals should choose personal deterrents that have undergone scientific testing and decide upon the best option likely to provide sufficient peace of mind for an 	

<p>individual. Many personal deterrents come with manufacture caveats that they are not 100% effective all the time in all situations.</p> <p>The DPI has funded a number of grants to investigate personal protection technologies, and collaborated with other entities to trial these – information about this can be found on their SharkSmart website.</p>	
<p>What are the advantages and disadvantages of personal shark deterrents?</p>	<p>Having heard about SDs – how would you compare them with personal shark deterrents?</p> <p>Effectiveness</p> <p>Bycatch</p> <p>Lethality</p> <p>Cost</p>
<p>Wrap up – min 80 6.50</p>	
<p>How has the trial of SMART drumlines influenced your attitudes to shark and beach management in this region?</p>	<p>Now experienced SDs, how do you feel about the use of mesh nets? If not covered – are SDs appropriate here?</p>

Appendix 4. Map of SMART drumline trials -Tathra



Appendix 5. Map of SMART drumline trials – Pambula



Appendix 6. Map of SMART drumline trials – Newcastle



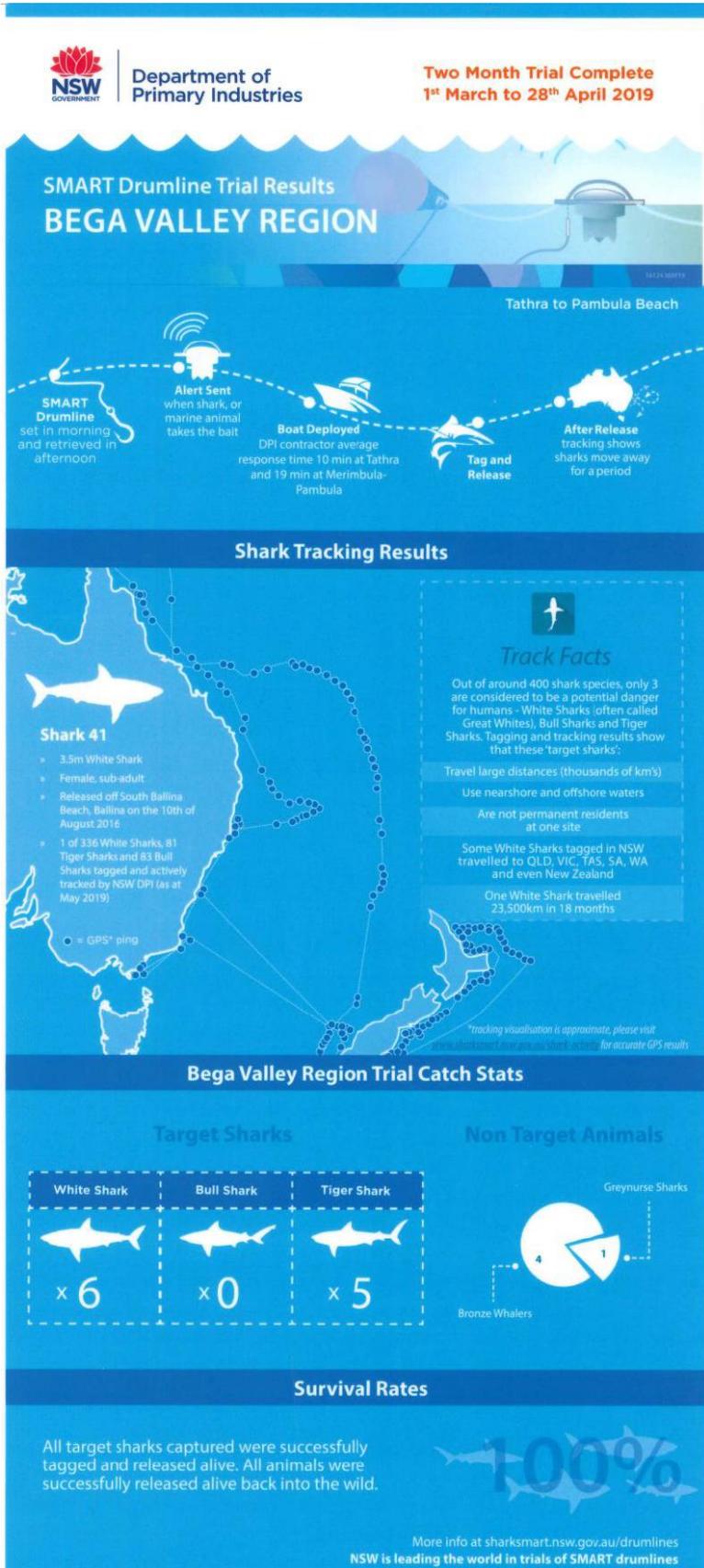
Appendix 7. Map of SMART drumline trials –Sydney Avalon



Appendix 8. Map of SMART drumline trials – Freshwater



Appendix 9. SMART drumline trial Infographic Bega Valley



Appendix 10. SMART drumline trial Infographic Newcastle



Department of Primary Industries

Stockton to Merewether Beach

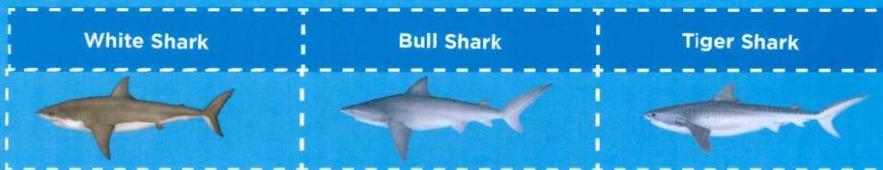
SHARK NETS AND SMART DRUMLINES

Results from the Newcastle region trial

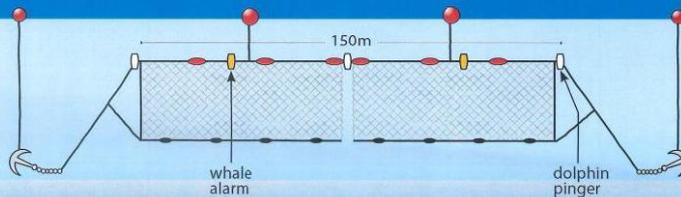
JN16174/06/19

A three month trial of SMART drumlines was completed from 1 February – 30 April 2019 to coincide with shark netting season (1 September - 30 April each year) to compare the catch results.

Target Sharks



Shark nets - catch data



Target Sharks

2

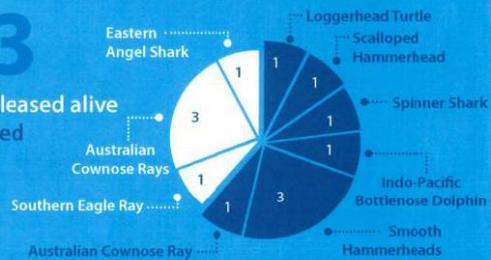
0 released alive
2 died



Non-Target Animals

13

5 released alive
8 died

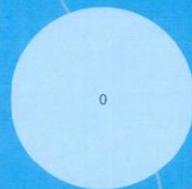


SMART Drumlines - catch data

Target Sharks

0

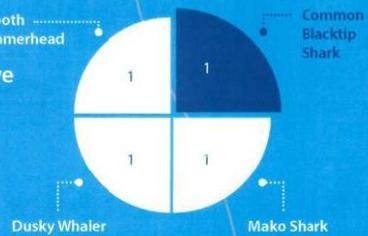
0 released alive
0 died



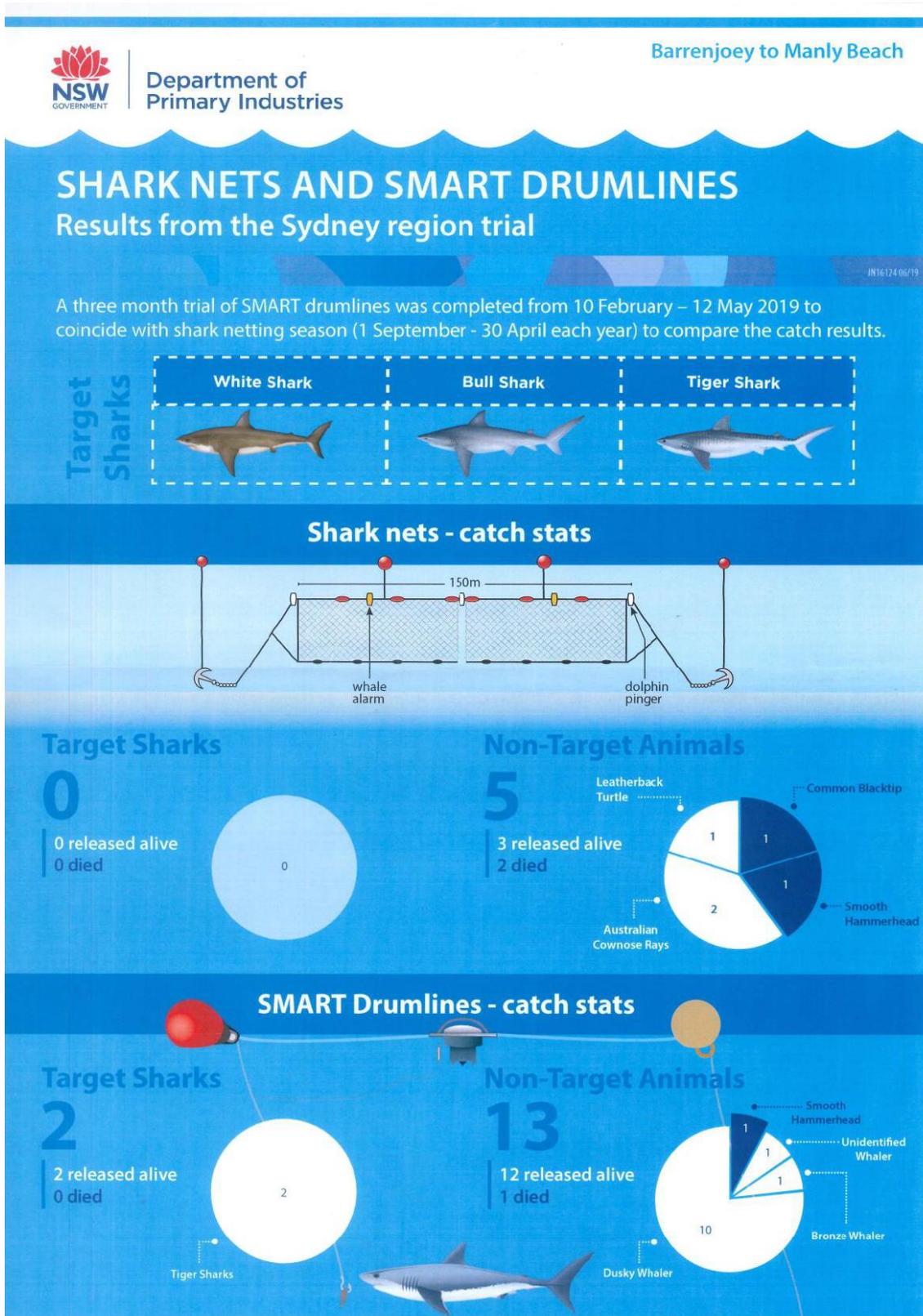
Non-Target Animals

4

3 released alive
1 died



Appendix 11. SMART drumlines trial infographic Sydney Northern Beaches



8

APPENDICES

Alessa, L. N., Kliskey, A. A. & Brown, G. (2008). Social-ecological hotspots mapping: A spatial approach for identifying coupled social-ecological space. *Landscape & Urban Planning*, 85, 27-39.

Crossley, R., Collins, C M, Sutton, S G and Huveneers, C. (2014). Public perception and understanding of shark attack mitigation measures in Australia. *Human Dimensions of Wildlife*, 19: 154-165.

Francis, B. (2011). *Before and After Jaws: Changing Representations of Shark Attacks* (Honours thesis). Murdoch University, Perth, Australia. Retrieved from:

<https://pdfs.semanticscholar.org/8af5/d7f75b46cf1b9cd9b638a0b369c0f1212a20.pdf>

Gibbs, L & Warren, A (2015). Transforming shark hazard policy: Learning from ocean-users and shark encounter in Western Australia. *Marine Policy*, 58: p. 116-124. DOI: 10.1016/j.marpol.2015.04.0414

Huveneers, C., Whitmarsh, S., Thiele, M., Meyer, L., Fox, A. and Bradshaw, C.J.A. (2018). Effectiveness of five personal shark-bite deterrents for surfers. *PeerJ* 6:e5554; DOI 10.7717/peerj.5554.

Kansky, R, & Knight, AT (2014). Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation*, 179, 93-105.

Krueger, RA, & Casey, MA, (2014). *Focus groups: A practical guide for applied research*, Sage.

Lewandowski, J. (2015). Transforming Wicked Environmental Problems in the Government Arena. *Human-Wildlife Conflict: Complexity in the Marine Environment*, 39.

DOI:10.1093/acprof:oso/9780199687145.001.0001

McCagh, C, Sneddon, J & Blache, D (2015). Killing sharks: The media's role in public and political response to fatal human-shark interactions. *Marine Policy*, 62, 271-278. DOI: 10.1016/j.marpol.2015.09.016

Mehmet, M & Simmons, P (2016). Kangaroo court? An analysis of social media justifications for attitudes to culling. *Environmental Communication*, 2016. 1-17. <https://doi.org/10.1080/17524032.2016.1220966>

Patton, M, (2015). *Qualitative Research & Evaluation Methods (4th edition)*, Sage.

Pepin-Neff, C and Wynter, T (2018) Shark bites and shark conservation: An analysis of human attitudes following shark bite incidents in two locations in Australia. *Conservation Letters*, 11: 1-8.

NSW Department of Primary Industries (DPI). (2017). *NSW north coast shark-meshing trials final report*. NSW DPI Fisheries Final Report Series No. 154. Retrieved from: https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0009/734535/NSW-north-coast-shark-meshing-trial-final-report.pdf

NSW Department of Primary Industries (DPI). (2018a). *Second NSW north coast shark-meshing trials final report*. NSW DPI Fisheries Final Report Series No. 157. Retrieved from: https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0009/829458/second-north-coast-shark-meshing-final-report.pdf

NSW Department of Primary Industries (DPI). (2018b). *Assessment of the attitudes of beach and ocean users to shark mitigation following SMART Drumlins trials in NSW*, NSW Shark Management Strategy. Retrieved from: https://www.sharksmart.nsw.gov.au/_data/assets/pdf_file/0011/871688/assessment-of-the-attitudes-of-beach-and-ocean-users-to-shark-mitigation-following-smart-drumline-trials-in-nsw.pdf

Saldaña, J, (2015). *The coding manual for qualitative researchers*, Sage.

Simmons, R., Mehmet, M. and Clarke, R.J. (2017). *Shark sentiment report*. Retrieved from: https://www.sharksmart.nsw.gov.au/_data/assets/pdf_file/0005/871808/Shark-Sentiment-Report.pdf

Simmons, P. and Mehmet, M. (2018). Shark management strategy policy considerations: Community preferences, reasoning and speculations, *Marine Policy*, 96: 111-119

Sturma, M. (1986). The Great Australian Bite: Early Shark Attacks and the Australian Psyche. *The Great Circle*, 8:78-81.

Taylor, J., McLean, L., Korner, A. and Glozier, N. (2019). Direct and indirect psychological impacts of shark-bite events. *Australian & New Zealand Journal of Psychiatry*, 53: 27-36.

Walton, T, & Shaw, WS (2017). Land-beach-risk-scape: deciphering the motivators of risk-taking at the beach in Australia. *Social & Cultural Geography*, 18(6), 869-886.

West, J G (2011). Changing patterns of shark attacks in Australian waters. *Marine and Freshwater Research*, 62: 744-754.